DEVELOPMENT OF CELLULOSE FROM WATER HYACINTH AND ELEPHANT GRASS.

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OUTLINE.

- **Introduction.**
- **Literature Review.**
- **Problem Statement.**
- **Justification of Study.**
- **Objectives.**
- **Methodology.**
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- **Acknowledgements.**

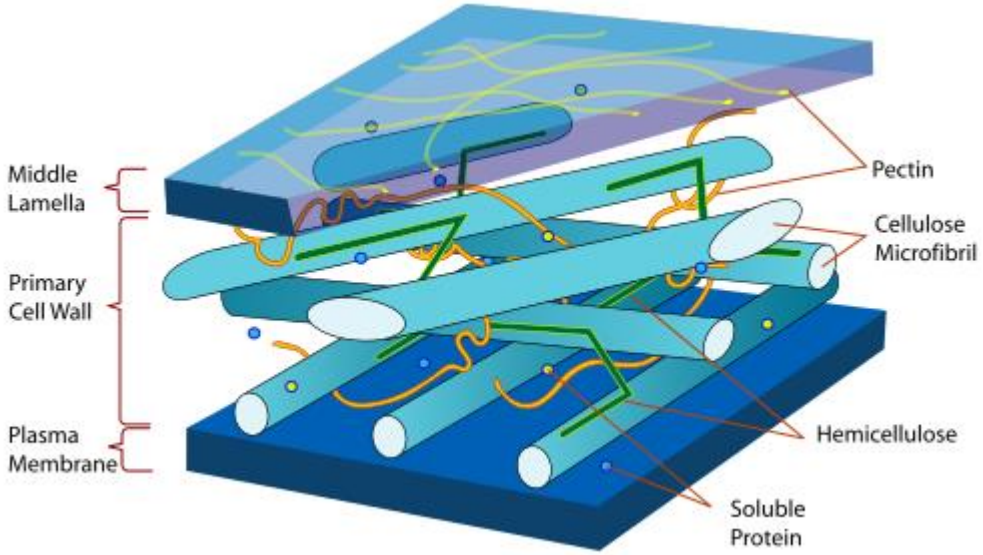
INTRODUCTION &LITERATURE REVIEW.

- Cellulose is the most abundant, renewable & biodegradable carbohydrate found in all plant fibers. It's a linear polysaccharide made of a thousand units of D-(+)-glucose units linked together by β-1-4-glycosidic linkages.
- Structural polymer- gives plants their shape & rigidity of plant cells.
- Photosynthesis. (synthesize carbohydrates)
- *6CO2 + H2O6O2* → *C6H12O6 (glucose)starch, cellulose + H2O.*
- Plant fiber is mainly made up of hemicellulose, lignin & cellulose, of which cellulose is about 30-50% wood & more than 90% cotton.

Introduction & Literature review Cont'D.

- Cellulose is insoluble in water as it contains OH groups which form both intermolecular (C3 & C6) & intramolecular hydrogen (C2 & C6) bonds.
- It's linear and compact arrangement enhanced by the β-linkages also enables it to form fibrillar strands.
- Humans lack the enzyme β-glucosidase, hence, we cannot digest cellulose.
- Cellulose contains three free OH groups (C2,C3 and C6), modification of these sites can alter the chemical and physical properties of cellulose and has boasted its industrial application.

The arrangement of cellulose and other polysaccharides in a plant cell wall.



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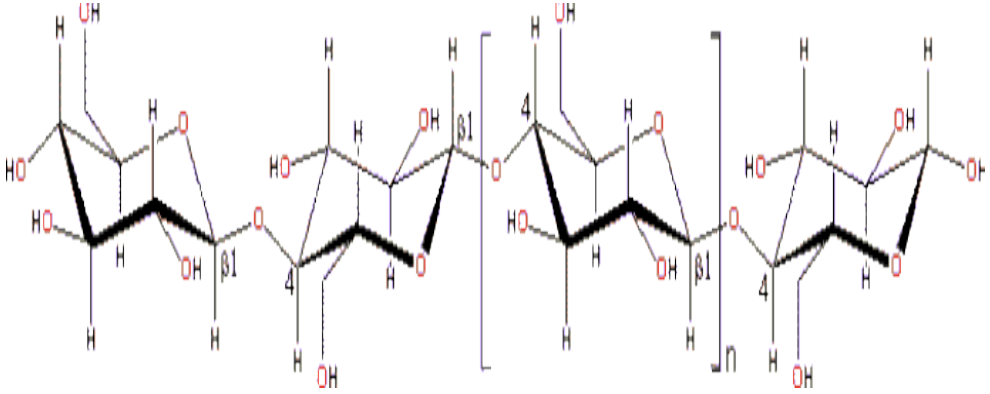
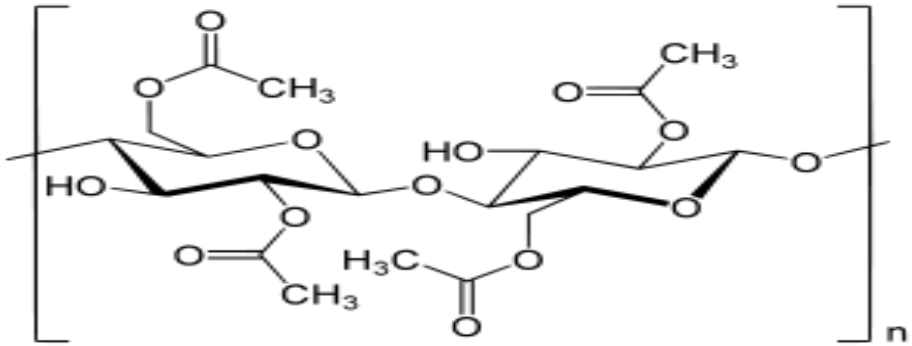
Introduction & Literature Review Cont'D.

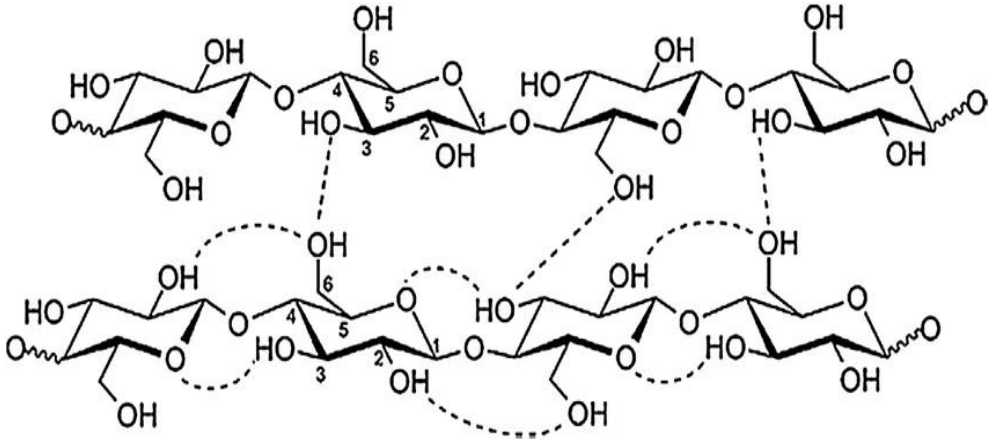
- Structure of Cellulose.



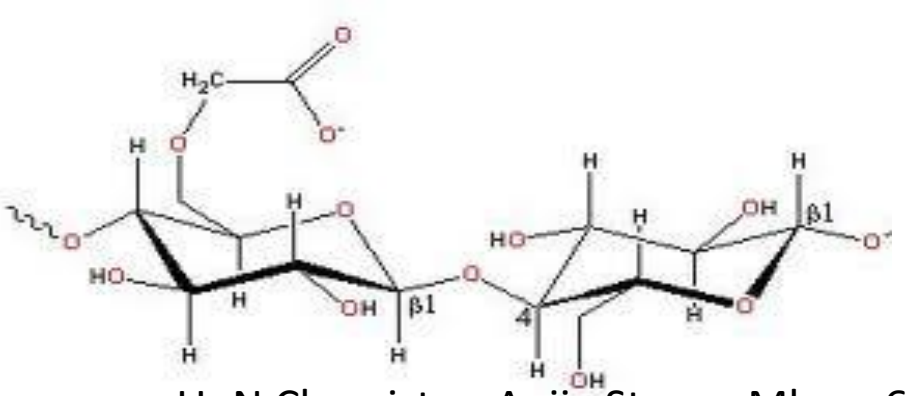
- Structure Cellulose Acetate.



- Intermolecular (C3-C6) & Intramolecular (C2-C6) HB.



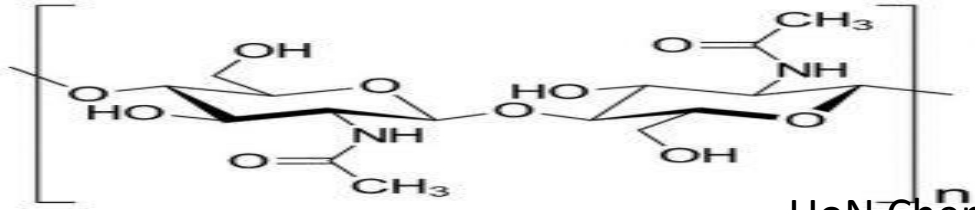
- Structure of Caboxymethyl Cellulose



Introduction &Literature Review Cont'D.

Modification of Cellulose.

- Chemical modification of cellulose through esterification (acetylation) has found great industrial application and it is also pocket friendly.
- The three OH groups can be modified through substitution reactions in the presence of a catalyst like sulfuric & perchloric acid. These catalyst speed up the swelling effect which leads to easier access & eventual breakage of the intermolecular HB.
- Chitin is the most abundant naturally occurring modified cellulose. It's a polysaccharide & is also linked up with β-1-4-glycosidic bonds.
- Chitin differs from cellulose at C-2 position, where cellulose has an OH group chitin has N-acetyl amino group. There linear alignment enhances their rigidity and insolubility in water.



Cellulose and Industries (Cont'D).

TYPE	REAGENTS	APPLICATION
Cellulose.	• Alkaline treatment & Acid hydrolysis of the biomass. • Soxhlet extraction, in a mixture of toluene/ethanol.	▪ Paper making. ▪ Cardboards and celling boards. ▪ Textile industries (Cotton). ▪ Laboratory equipment.
Cellulose nitrate.	• Reaction between cellulose nitric acid in the presence of H_2SO_4.	• Was used as a gun powder. • In photographic films.
Cellulose Acetate.	• Acetic acid, acetic anhydride, ethanol & H_2SO_4.	▪ Textile fiber. ▪ In photographic films. ▪ As a packaging materials.
Hydroethyl cellulose	• Cellulose is treated with alkaline solution, ethylene oxide & ethyl chloride	▪ Used in detergent & a shampoos as a thickener and builder.
chitin	• Naturally occurring modified cellulose	▪ Surgical treads as it is soluble within a period of time.

STATEMENT OF PROBLEM.

- Water hyacinth has drastic negative ecological and socio-economic effects on the inhabitants within the affected region.
- This project is aimed at addressing the pollution effects of water hyacinth in Kisumu, especially on the Lake Victoria.
- Ecologically, water hyacinth reduces the concentration of dissolved O2 which leads to eutrophication & alters the ecosystem biodiversity. Socio-economic effects include: paralyzes the water transport system, increases the spread of waterborne diseases, affects the fishing industries, interferes with the quality of water.
- Elephant grass is also a noxious plant as it can out-compete other plants easily and if left idle can be very difficult to eradicate.

RESEARCH QUESTIONS & OBJECTIVES.

- **Research Questions.**
  - Is it possible to extract cellulose from water hyacinth & elephant grass?
  - Can the structure of cellulose be modified?
  - Can the extracted cellulose be used to adsorb heavy metals from waste water of Chiromo River?

- **Research Objectives.**
  - **General Objectives.**
    - To find commercial material uses of invasive species i.e. water hyacinth & elephant grass.
  - **Specific Objectives.**
    - To isolate cellulose from water hyacinth & elephant grass.
    - To modify the structure of cellulose through acetylation.
    - To adsorb heavy metals from waste water using the extracted cellulose & AC.

JUSTIFICATION.

- Lake Victoria is the main hub of commercial activities in Kisumu, a source of water for domestic & industrial use, transportation & also tourist attraction.
- However, these benefits face the challenge of invasive fish & plant species (Nile perch & water hyacinth),discharge of industrial effluents & untreated sewage, climate change, increase in human population and activities.
- Water hyacinth is very difficult to eradicate by mechanical, biological & chemical control methods due to the huge capital, personnel, infrastructures & not forgetting the environmental & health effects that comes with these process.
- Elephant grass is also an invasive plant with high biomass content that lays mostly idle apart from being used as an animal feed stock & biogas production.
- Finding material use of these invasive plants therefore becomes the most effective method of controlling & eradicating these pollution effects.
- Cheaper waste water purification methods also needs to be outsourced in order to protect our environment & reduce the health effects as a result of exposer to toxic elements in the aquatic ecosystem.

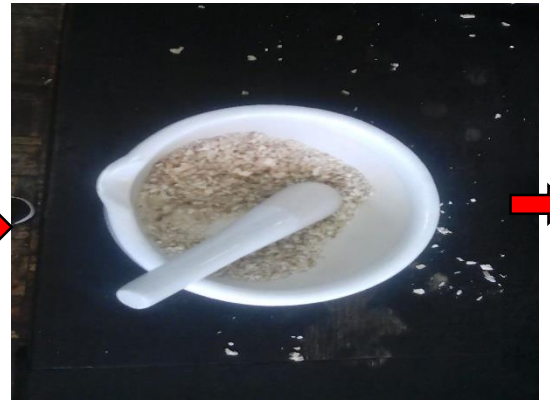
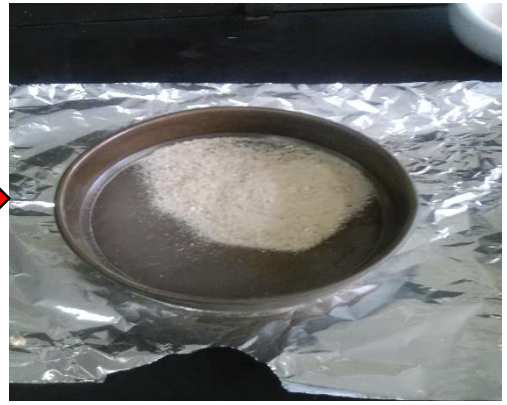
METHODOLOGY Cont'D.
Extraction of Cellulose.

Isolation.

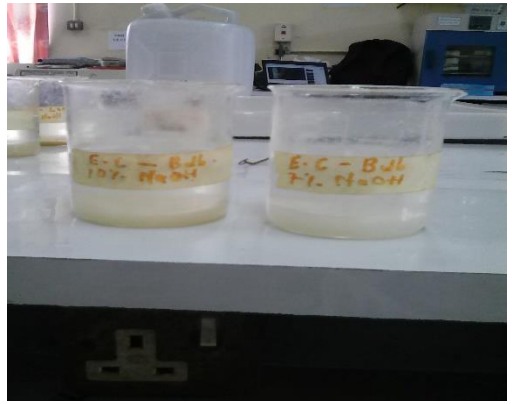
- **Alkaline treatment.**
- **Acid Hydrolysis.**
- **Bleaching.**

Reagents.

- **NaOH (7% & 10%), HNO3 (3.5 % 5 M) at 500C**
- **4:1 3% $NaClO_2$/CH_3COOH at 80^0C for 2 Hours.**






Methodology Cont'd. Acetylation.

- In terms of supplies we need glacial acetic acid, acetic anhydride, H_2SO_4 acid (catalyst) and a source of cellulose (water hyacinth).
- Modification of cellulose involves two main steps i.e. Pretreatment and Acetylation.

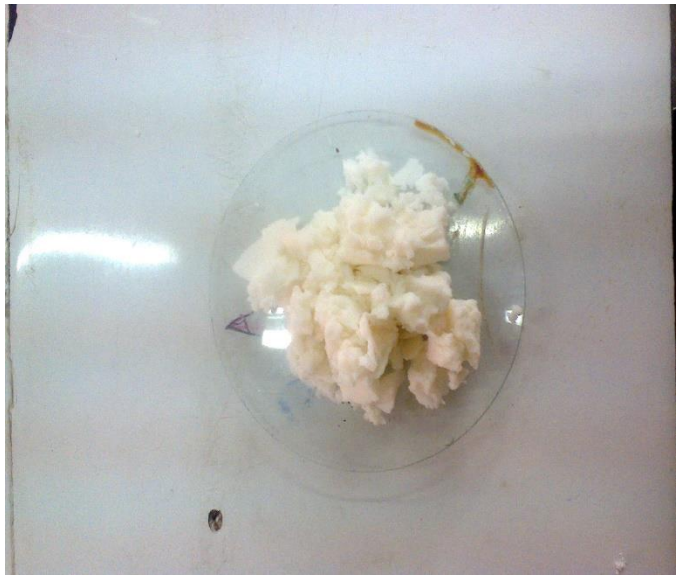
Methodology Cont'd Pretreatment.

- Weigh 10g of the Cellulose Sample and place it in a conical flask.
- Add a mixture of 50ml acetic acid + 0.5g H_2SO_4 (Catalyst).
- Cover the top as tightly as possible.
- Leave the content for an hour with constant stirring.
- This process helps in the access of OH groups & breakage of the tightly packed cellulose chain. Breakage of the intramolecular & intermolecular hydrogen bond is also enhanced.

Methodology Cont'd.
Acetylation.

- Add to the content 50ml acetic anhydride + 20ml acetic acid.
- Cover the top of the flask and place in a water bath held at 50^{o}C.
- Let the reaction run for 30 minutes.
- It is expected that all the cellulose should dissolve in the acid mixture otherwise repeat the pretreatment process.
- Separate the content equally into two 250ml round bottomed flask i.e. One for the synthesis of cellulose triacetate & the other for cellulose diacetate.

Methodology Cont'd.
Acetylation.



UoN Chemistry: Anjia Steven Mbae, 6 June 2018

Methodology Cont'd.

Cellulose Triacetate.

- Return the content into the water bath & hold the temp^{o} slightly hotter at 60^{o}C.
- Add a stirrer bar and slowly add 80% acetic acid. The reaction is highly exothermic & temp^{o} beyond 60^{o}C could lead to the loss of the acetate in the acid mixture.
- Precipitate with distilled water slowly with stirring.
- Let the mixture settle & vacuum filter while washing with distilled water to remove acidity until odorless.
- Dry in the oven at a lower heat, pulverize the extract & run through an FTIR. (The product is waxy as a melted candle when still wet).

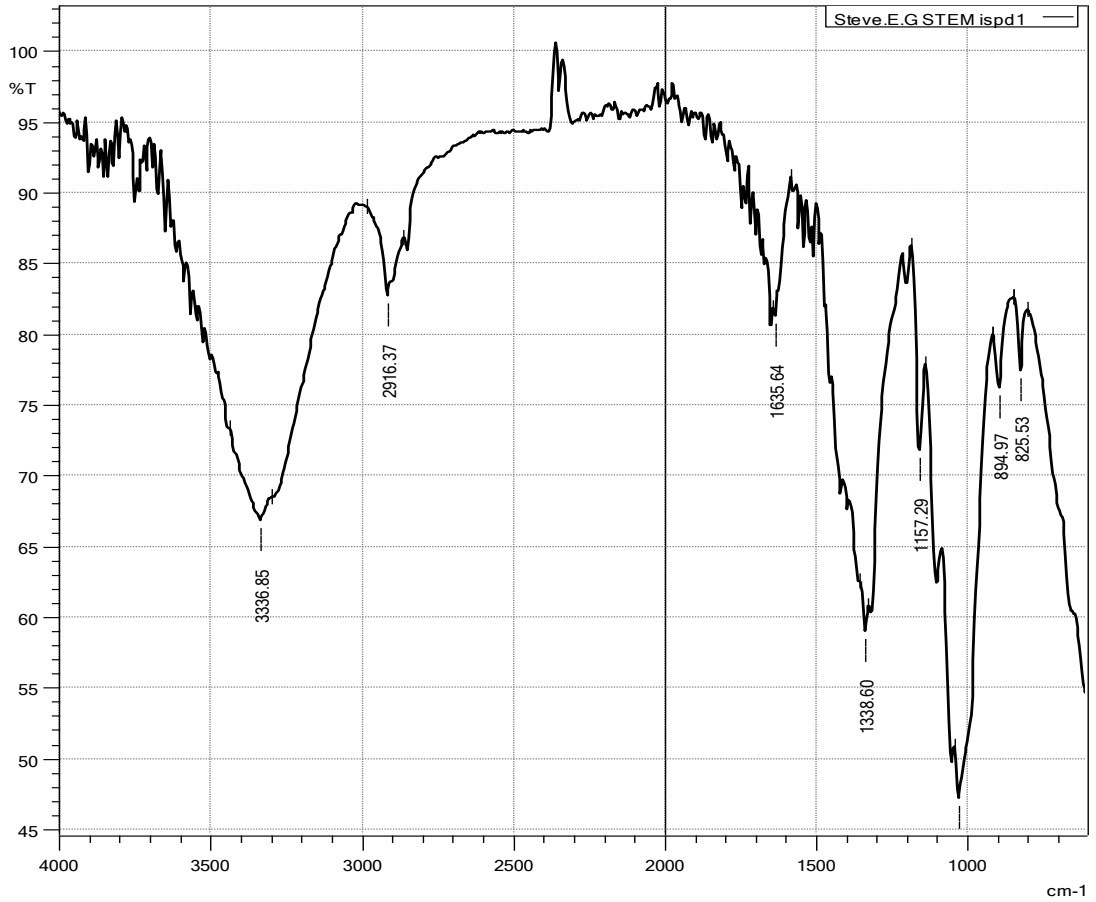
Cellulose Diacetate.

- Return the content into the water bath & let it stabilize at 60^{o}C.
- Add a stirrer bar and slowly add a mixture of 70% acetic acid + 0.15g H_2SO_4.
- Run the reaction for 3 hours. Pour the content into the beaker and precipitate it by slowly adding distilled water.
- Vacuum filter, dry in an oven & characterize using FTIR.
- N/B: H_2O is mainly added to dissolve the excess acetic anhydride while acetic acid is added to help dissolve the cellulose even further.

RESULTS & DISCUSSION.

Cellulose Spectrum (Stem).

10% NaOH Solution.

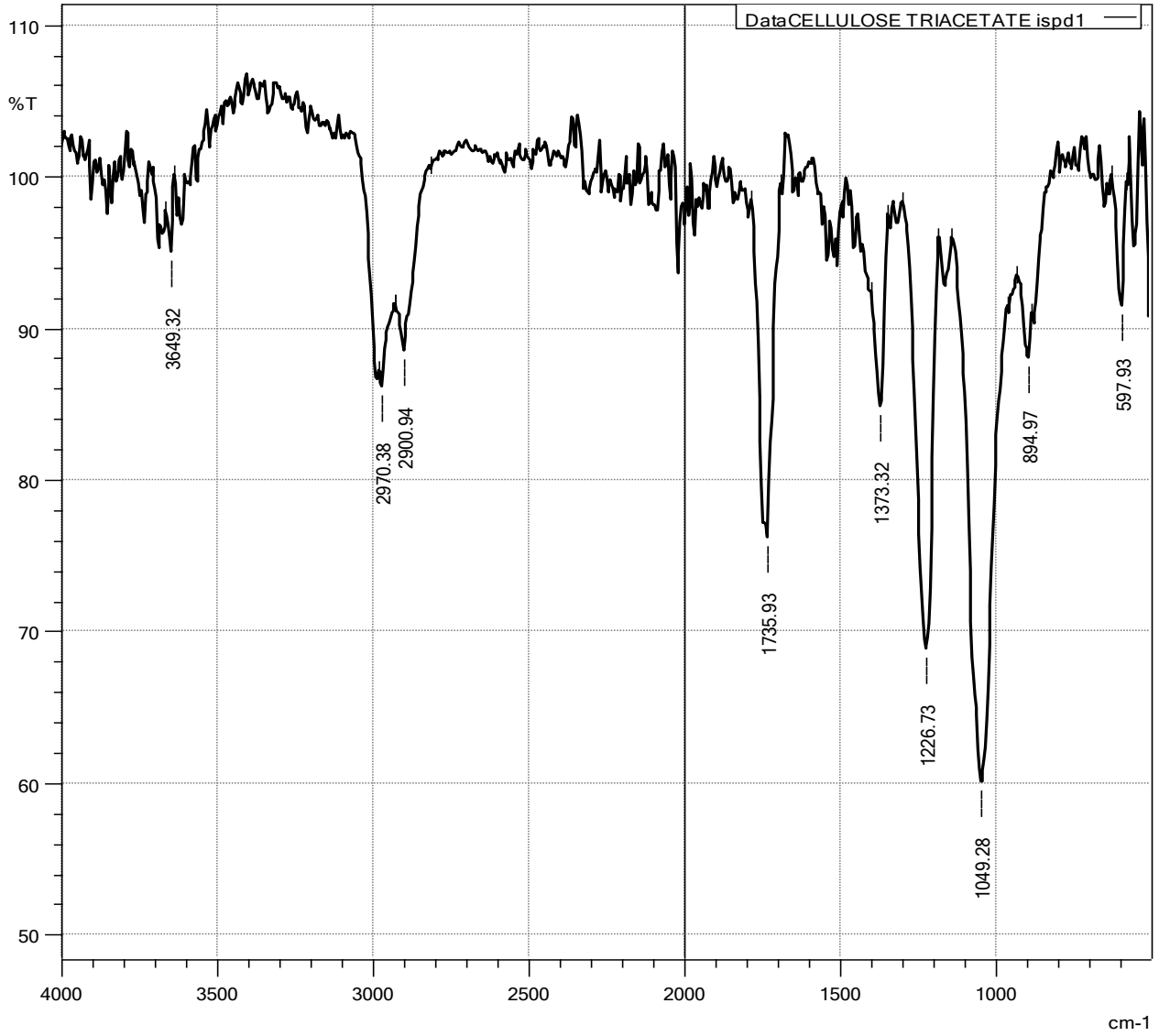


Cellulose Spectrum Interpretation.

- Spectrum btn. 3387-3336cm-1 indicate OH stretching groups. Hence presence of HB & alcohol groups.
- 2920-2900 cm-1 indicate the presence of C-H sp3 vibrational mode.
- 1056-1026 cm-1. C-O stretching bands indicating the presence of β-linkages. Also a characteristic feature of alcohols
- Bands at 894-891 cm-1. C-O-C absorption bands. Also indicates the presence of β-linkages.

RESULTS & DISCUSSION Cont'D.

Cellulose Triacetate Spectrum.

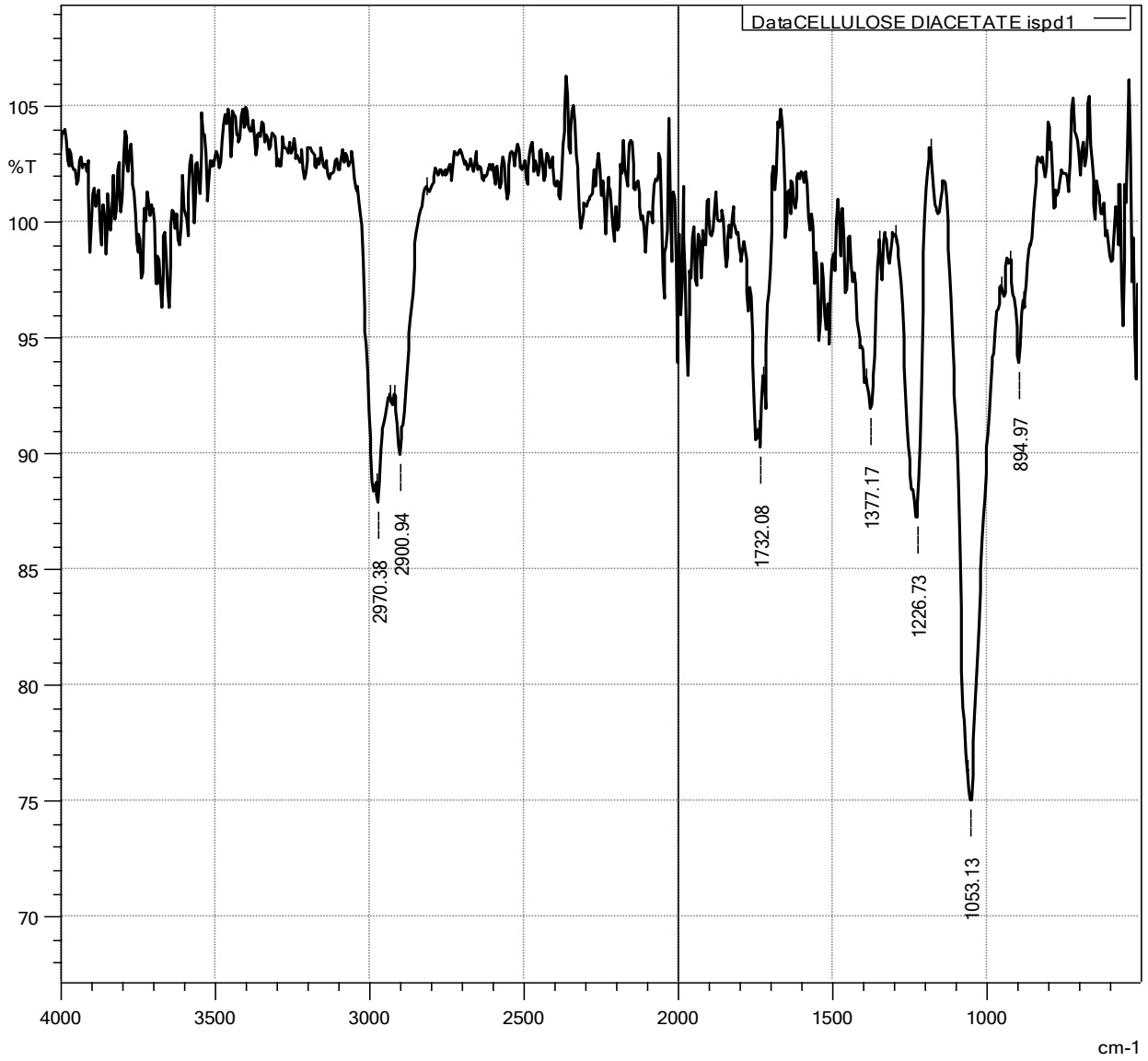


Acetylated Cellulose IR Analysis.

- Lack of absorption peaks of OH stretching groups at 3305.99 cm-1 indicate that all the OH groups were successfully substituted during the acetylation process.
- Sharp intense peaks at 1735.93 cm-1 for carbonyl groups (C=O), confirms the presence of ethyl acetate of the aliphatic esters & successful esterification through acetylation.
- Peaks at 2970.38-2900.94 cm-1 indicate the presence of C-H sp3 vibrational modes.
- Peaks at 1049.28 cm-1 indicate the presence of C-O groups. Characteristic of alcohol groups & β-linkages.

Results & Discussion Cont'd

Cellulose Diacetate Spectrum.



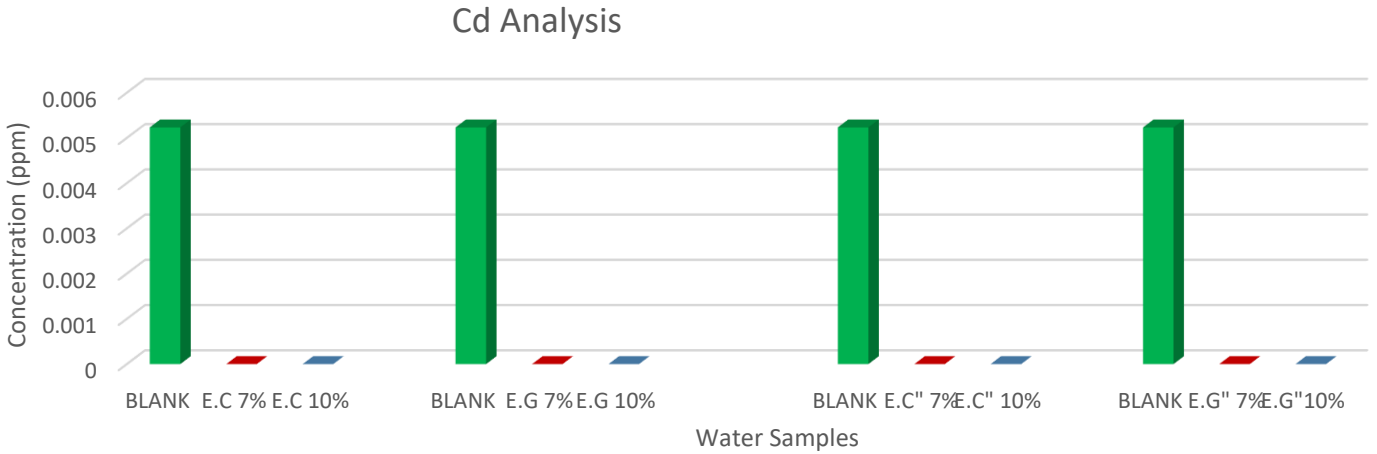
Cellulose Diacetate IR Analysis.

- Peaks at 1732.08 cm-1 indicate the presence of C=O functional groups. This indicates successful modification of the cellulose structure.
- 2970.38-2900.94 peaks indicate the presence of C-H sp3 vibrational groups for alkyl groups.
- Lack of OH peaks indicates that substitution of its active sites was achieved.
- N/B: The Triacetate has more intense peaks of the C=O functional groups than the Diacetate one which could indicate that the triacetate analyte has more carbonyl groups per glucose units than the diacetate analyte.

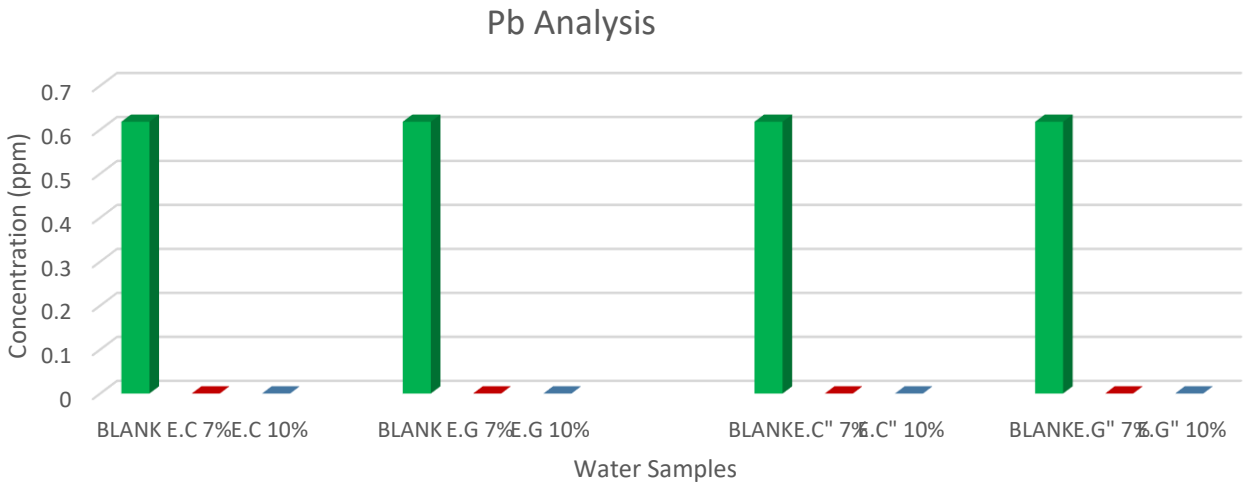
RESULTS AND DISCUSSION Cont'D.

Adsorption Analysis.

- Cd Analysis. 0.005±0.0008ppm



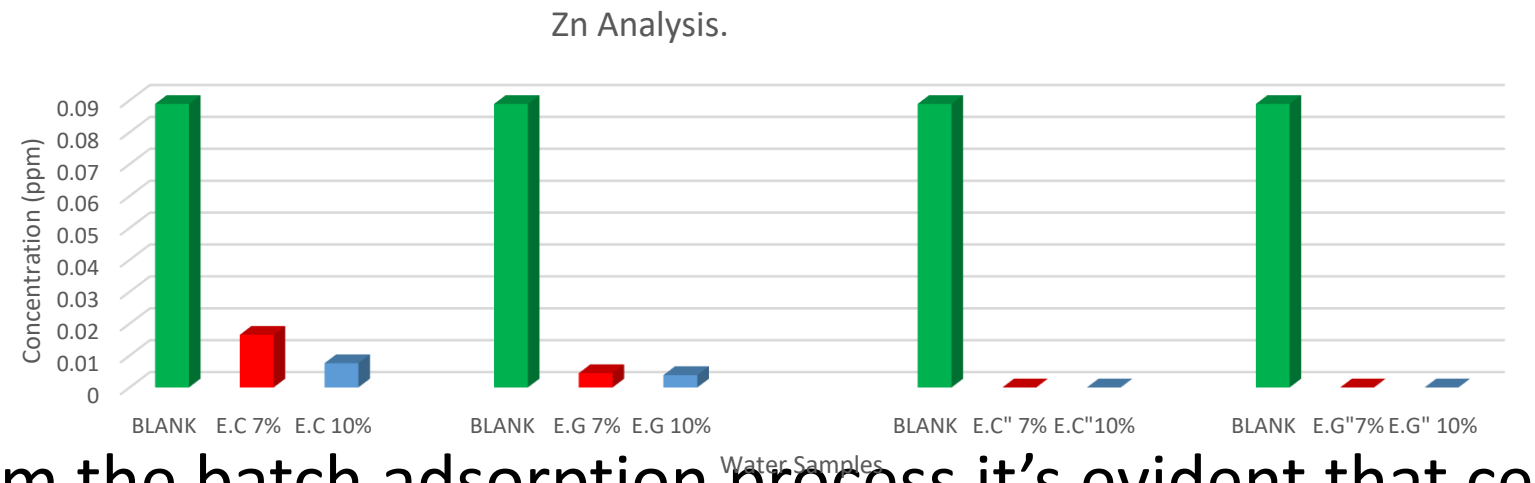
- Pb Analysis. 0.6179±0.06568ppm



RESULTS & DISCUSSION Cont'D.

Adsorption Analysis.

- Zn Analysis. 0.08887±0.00952ppm



- From the batch adsorption process it's evident that cellulose & AC products can be used as a cheaper waste water purification method.
- It also indicated that Cd & Pd conc.at Chiromo River were beyond the WHO permissible levels in drinking water. Zn recorded the lowest conc. WHO limits: Cd 0.001mg/L, Pb 0.003mg/L & Zn as 3.000mg/L.

CONCLUSION.

- The problem of invasive plants & subsequent pollution of aquatic ecosystem can potentially be solved by finding material use of invasive plants.
- It is possible to develop cellulose from water hyacinth and elephant grass (bleached pulp).
- The structure of cellulose can be modified. Presence of sharp & intense Carbonyl group peaks (C=O at 1732-1716 cm-1) which is a characteristic of ester groups.
- Cheaper waste water purification methods can be found as is evident in the batch adsorption results.
- Cellulose synthesized with higher conc. of alkaline solution formed the best adsorbent for heavy metals.

RECOMMENDATIONS.

- Additional alternative applications of invasive plants should be explored as a source of biomass needed by industries.
- Modification of cellulose can be achieved successfully to form both the cellulose diacetate and cellulose triacetate.
- Cheaper methods of waste water purification should be adopted in order to prevent environment contamination & effects on human health through exposer to heavy metals.

ACKNOWLEDGMENTS.

- Prof Shem Wandiga.
- Lab technicians.
- My fellow students.
- Lecturers.