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Development of an adsorbent material to remove Fluoride from water

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Outline of the presentation

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- Objectives
- Methodology
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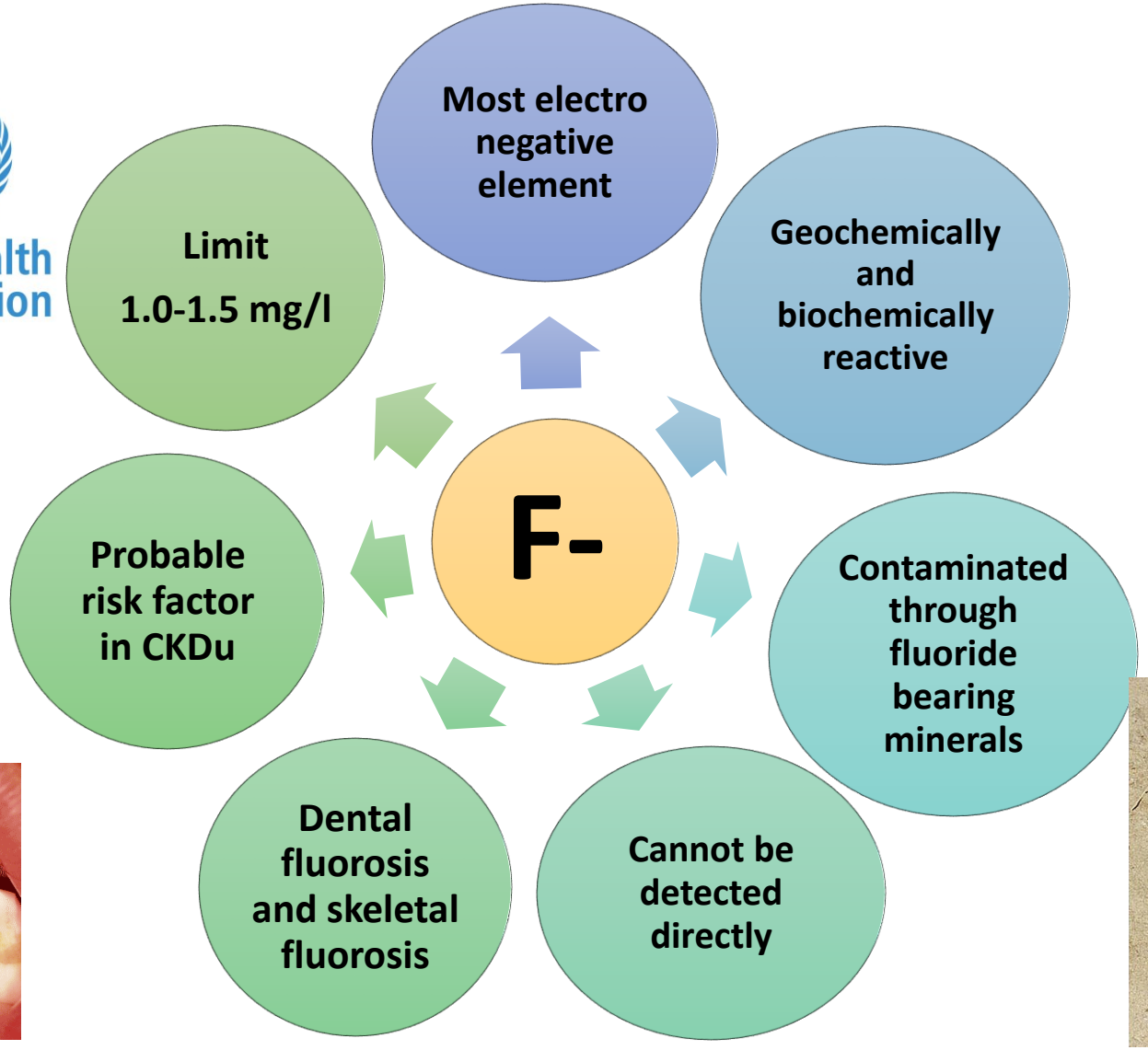
  - Protonated Chitosan Saw Dust Composite beads
  - Zero point charge test (pHzpc)
  - Sorption Experiments
  - Effect of Contact Time
  - Effect of Adsorbent dosage
  - Effect of Initial Fluoride Concentration
- Conclusion
- References

Introduction

World Health Organization

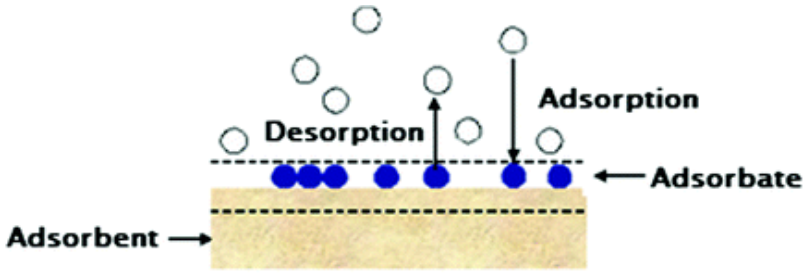
Chronic Kidney Disease of Unknown Etiology (CKDu)



Introduction

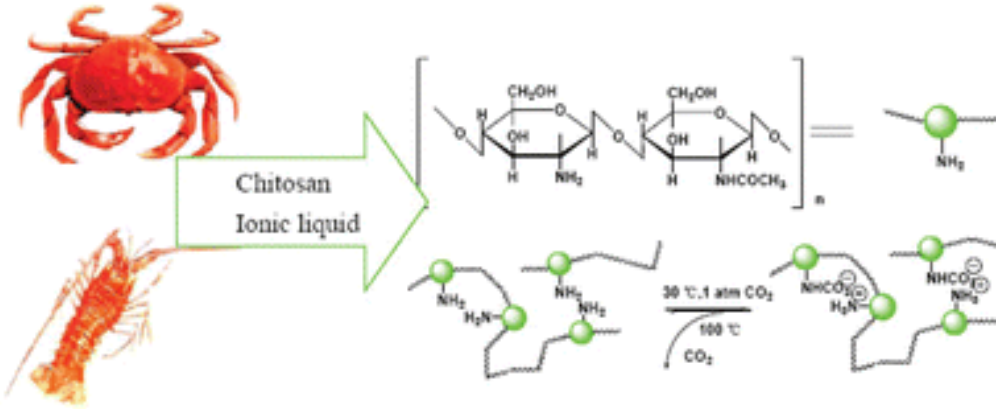
Adsorption process

- **<u>Adhesion of contaminant particles (adsorbate) on to the surface of adsorbent.</u>**
- Greater accessibility
- Low cost
- Simple operation
- Available of wide range of adsorbents



Biosorbents

- Low cost
- Safe and non-toxicity
- Naturally abundant
- Re-useable

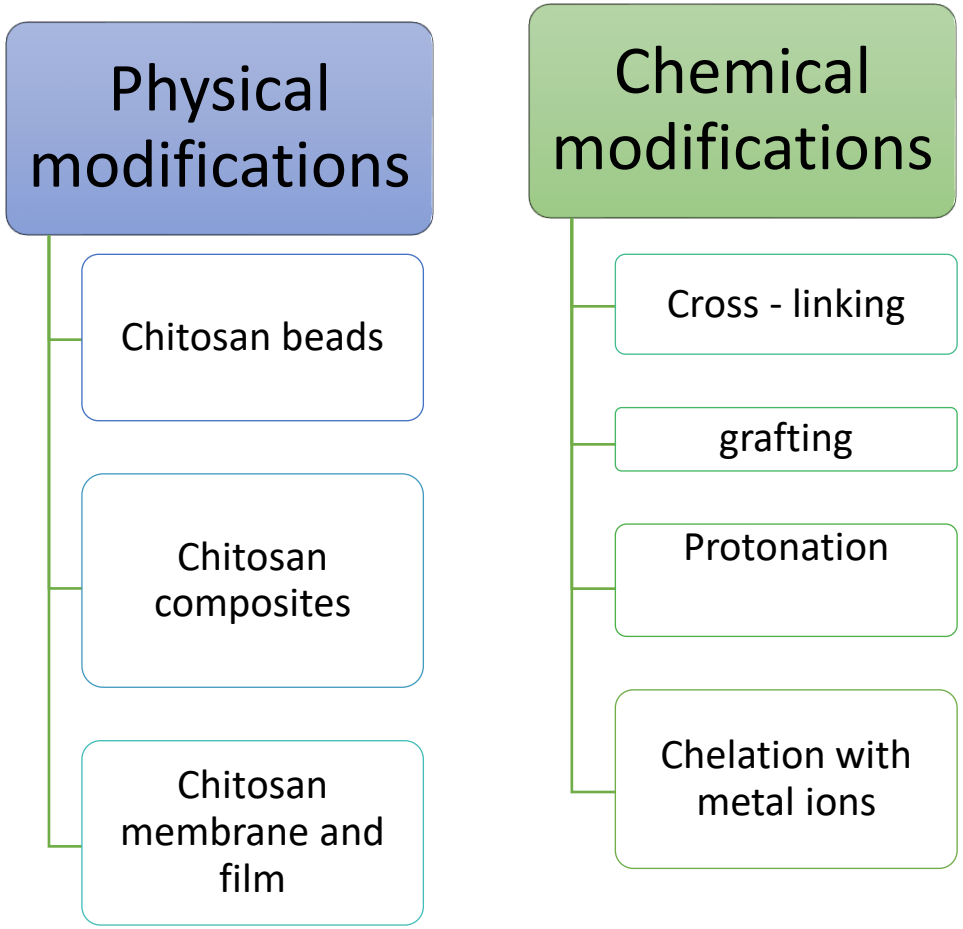


Chitosan

- Bio degradability
- A naturally occurring abundant biopolymer
- derived by de-acetylation of chitin
- Commercially extracted from shellfish processing waste.

Introduction

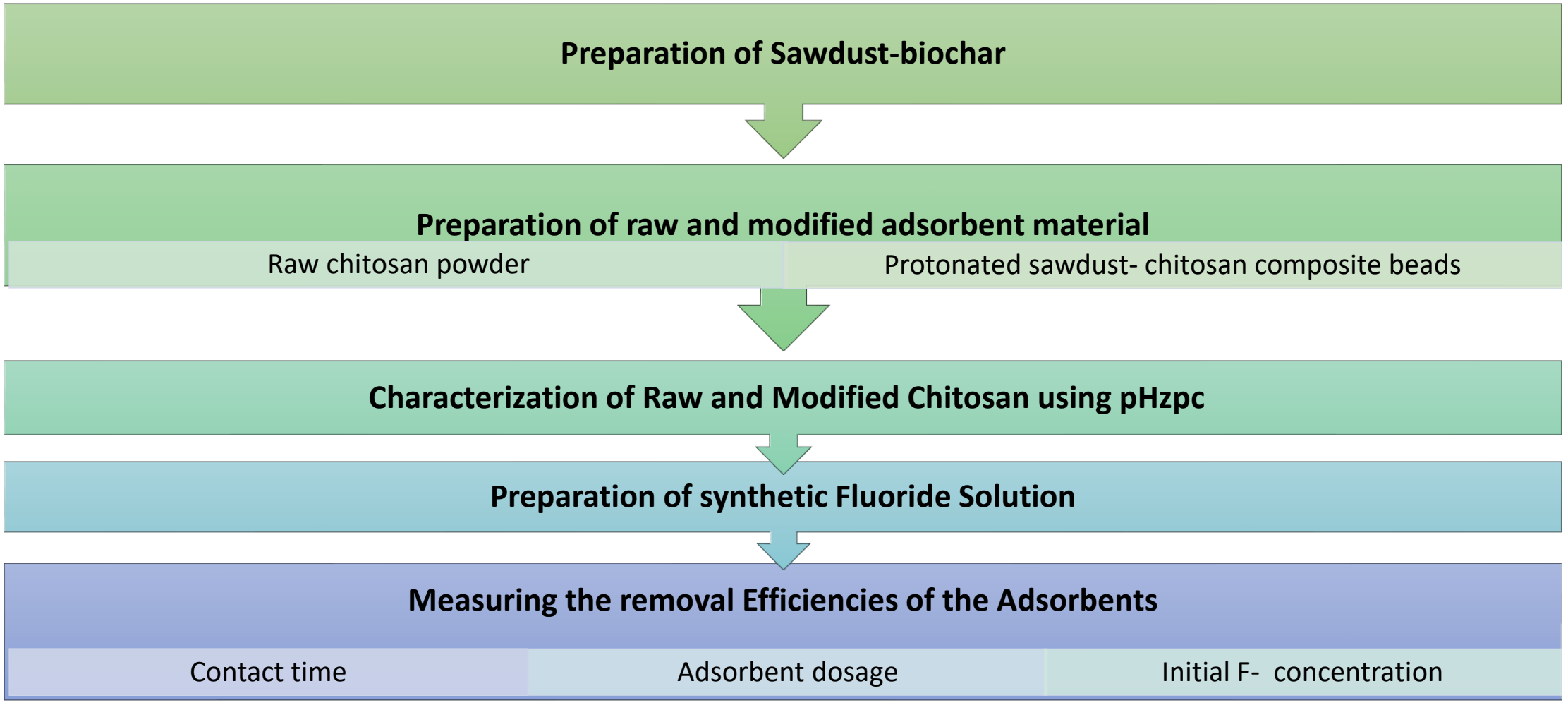
- Chemical and physical modifications are carried out to improve adsorption capacity of raw chitosan.



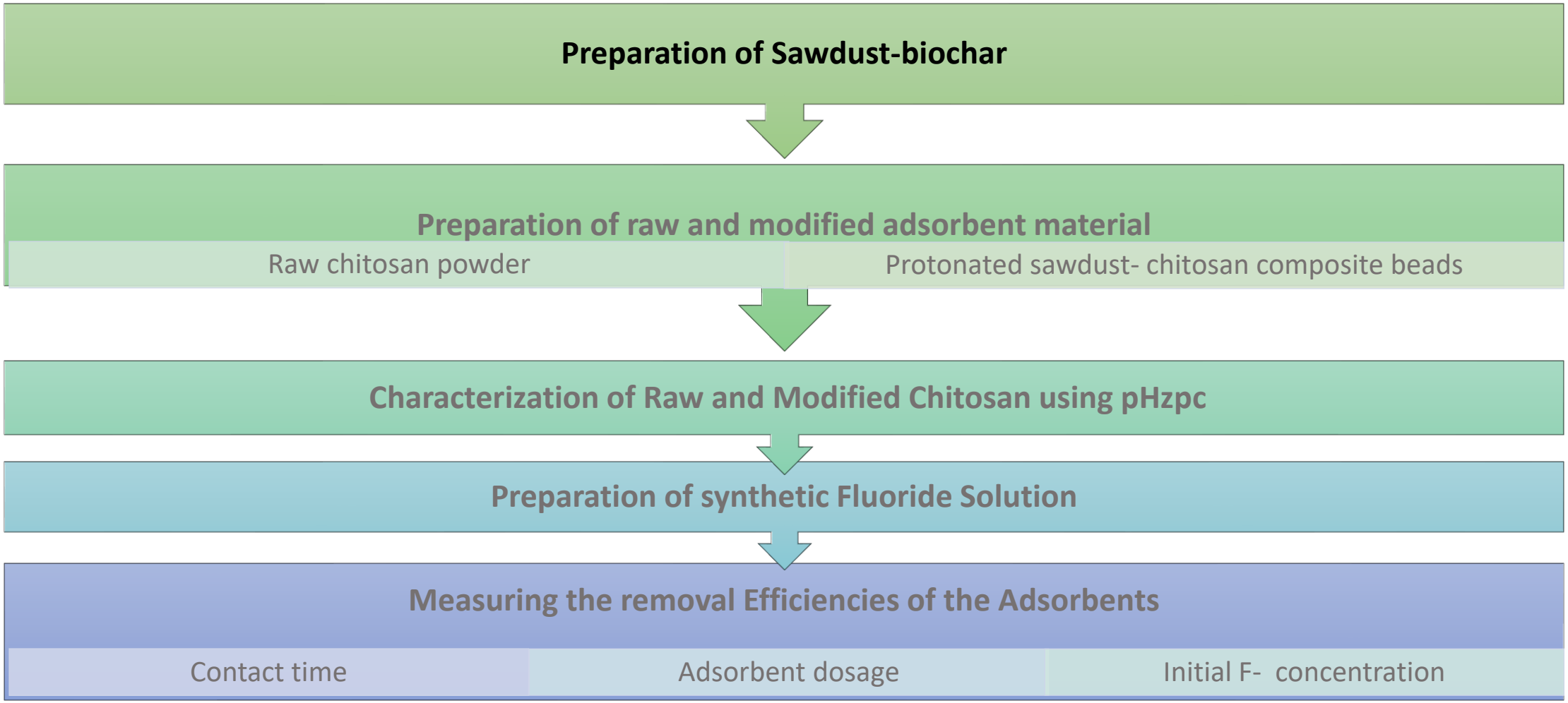
Objectives

- To develop a novel chitosan based adsorbent material.
- To analyze the efficiency of raw and modified chitosan adsorbents in removing fluoride from synthetic fluoride solution.

Methodology



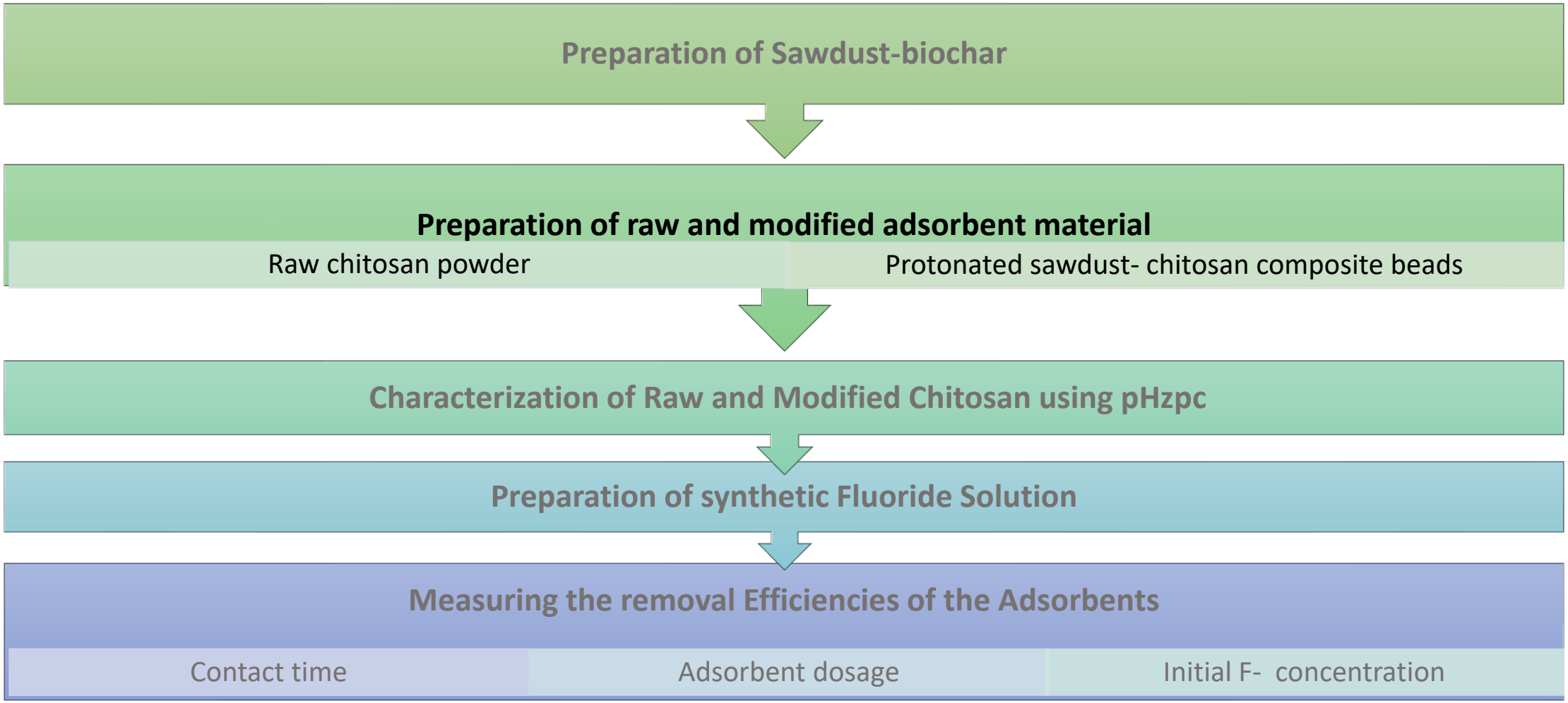
Methodology



Preparation of Sawdust- Biochar

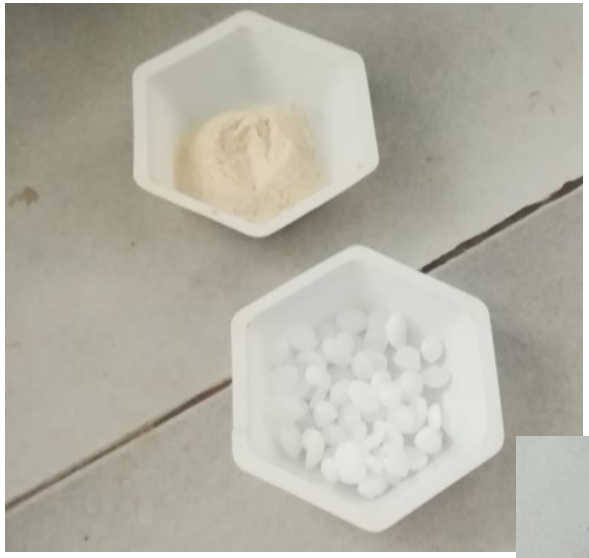
- Softwood sawdust was pyrolyzed using a. **Continuous Downdraft Double Chamber Slow Pyrolysis Reactor**
- Temperature range - **$550^0C – 660^0C$**
- The resulting biochar was washed several times with distilled water to remove any adhered impurities.
- Oven dried for **24 h at 37^0C**.
- The dried biochar was then grounded and sieved through a **75 micron sieve** and used for preparation of the modified adsorbent.

Methodology



Protonated Chitosan Saw Dust Composite beads

- Materials
  - Chitosan powder 1 g
  - Sawdust- Biochar 0.5 g
  - Acetic acid 1% (V/V) 100 ml
  - Sodium Hydroxide 1.0 M
  - Glutaraldehyde $C_5H_8O_2$ 2.5% (w/w)
  - Conc. HCL



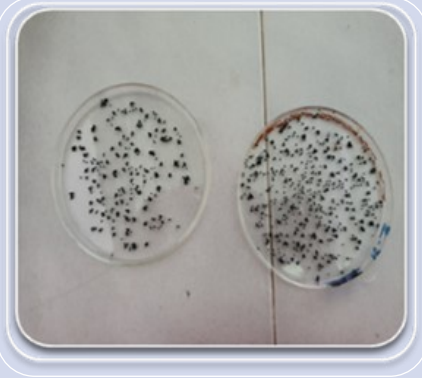
Preparation of Modified Chitosan beads

Chitosan solution was prepared by dissolving 1g of Chitosan and 0.5 g of powdered Saw dust powder into 100 ml of 1.0% (v/v) Acetic acid.

The solution was added drop wise to 1.0 M Sodium Hydroxide solution to prepare composite beads.

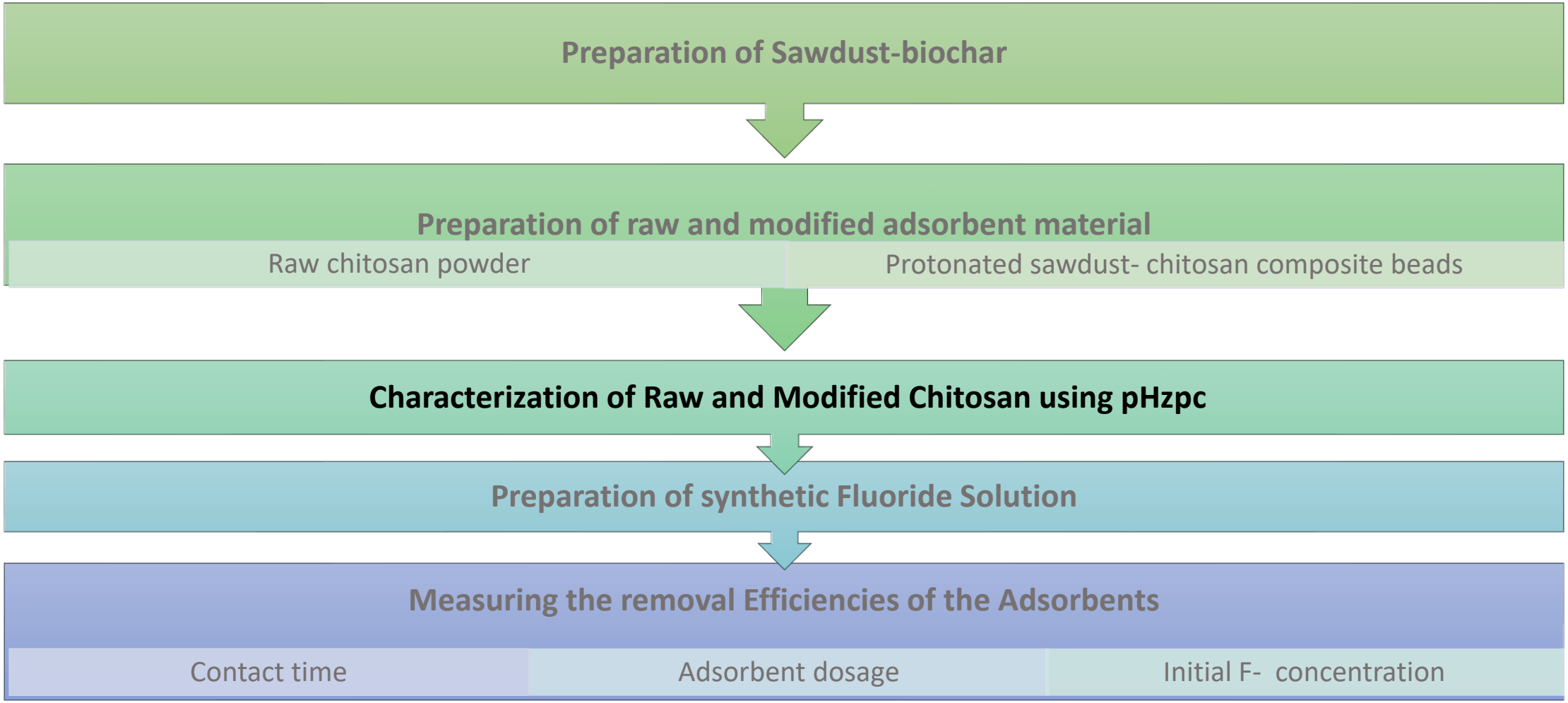
Wet sawdust chitosan composite beads were cross-linked with 2.5 wt. % Glutaraldehyde solution for 48 hours.

Cross-linked beads were treated with concentrated HCl for 30 minutes for protonation of beads.



The wet composite beads were washed with distilled water until constant pH. Finally, the beads were dried at room temperature.

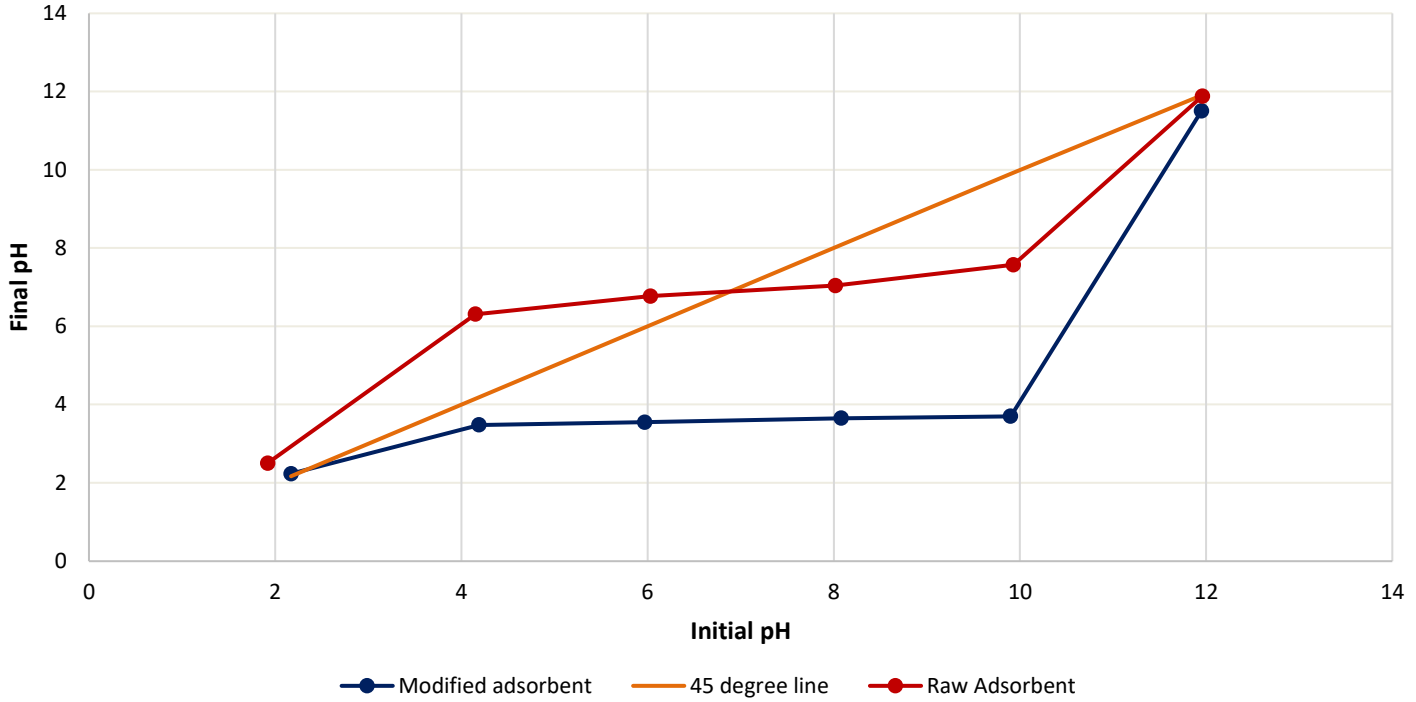
Methodology



Zero point charge test (pHzpc)

- Zero point charge (pHzpc) is the pH at which the surface charge of the material is zero in an aqueous media.
- Zero point charge of the adsorbent materials was determined using pH drift method.
- A series of pH solutions from **pH 2 to 12** was prepared by adding hydrochloric acid (HCl) and sodium hydroxide (NaOH) to distilled water.
- Raw Chitosan powder (**0.1g**) and Protonated Saw Dust Chitosan Composite beads (**0.1g**) were added to **25 ml** of pH solutions.
- The final pH vs. Initial pH graphs was plotted and The point of intersection of the resulting curve at 45 degree line gave the pHzpc.

Zero point charge test (pHzpc)

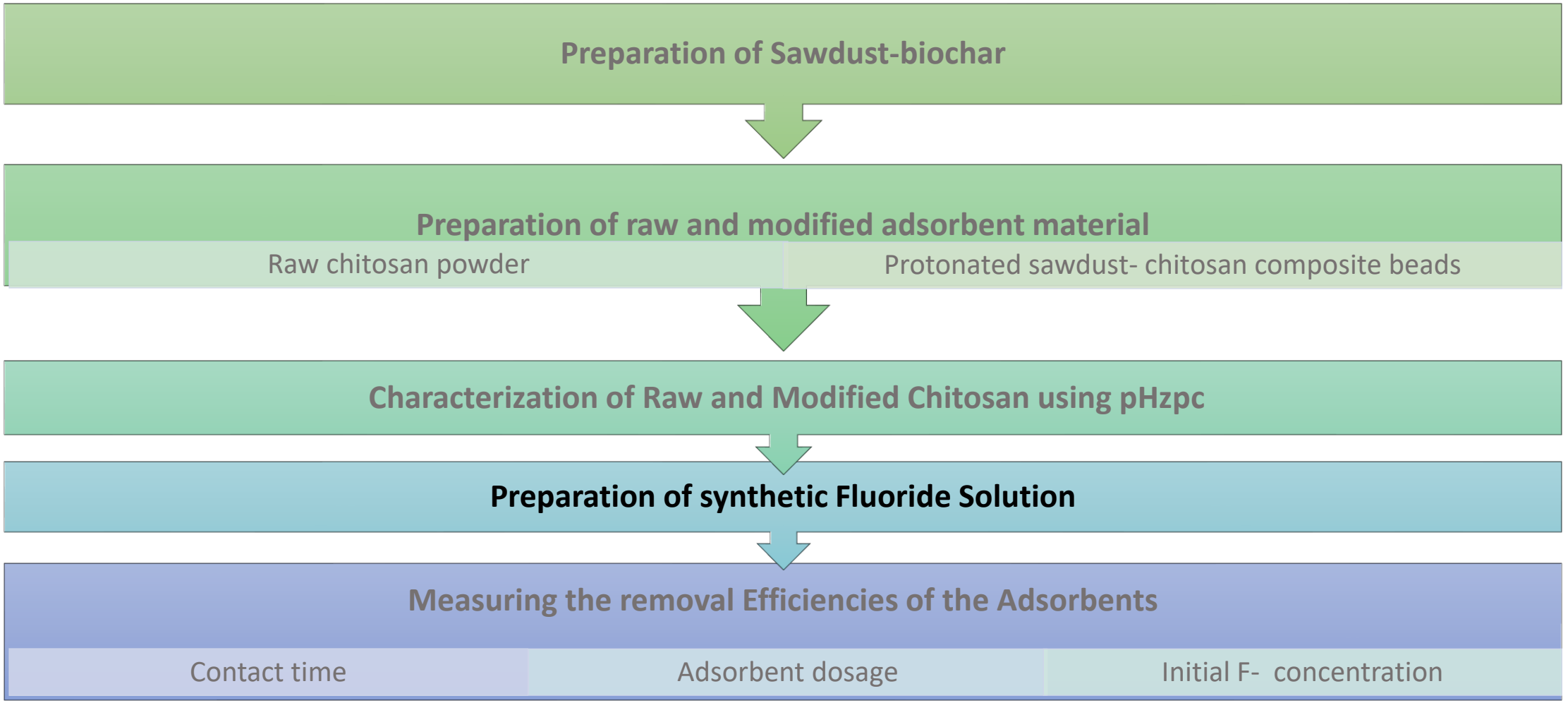


pH of zero point charge of Raw and Modified adsorbent

(Temperature = 25^0C; Contact time = 24 hours;
Adsorbent dosage = 4g/l; pH = 7)

Results: Zero point charge of raw chitosan powder – **7.00**
Zero point charge of modified beads – **2.20**

Methodology



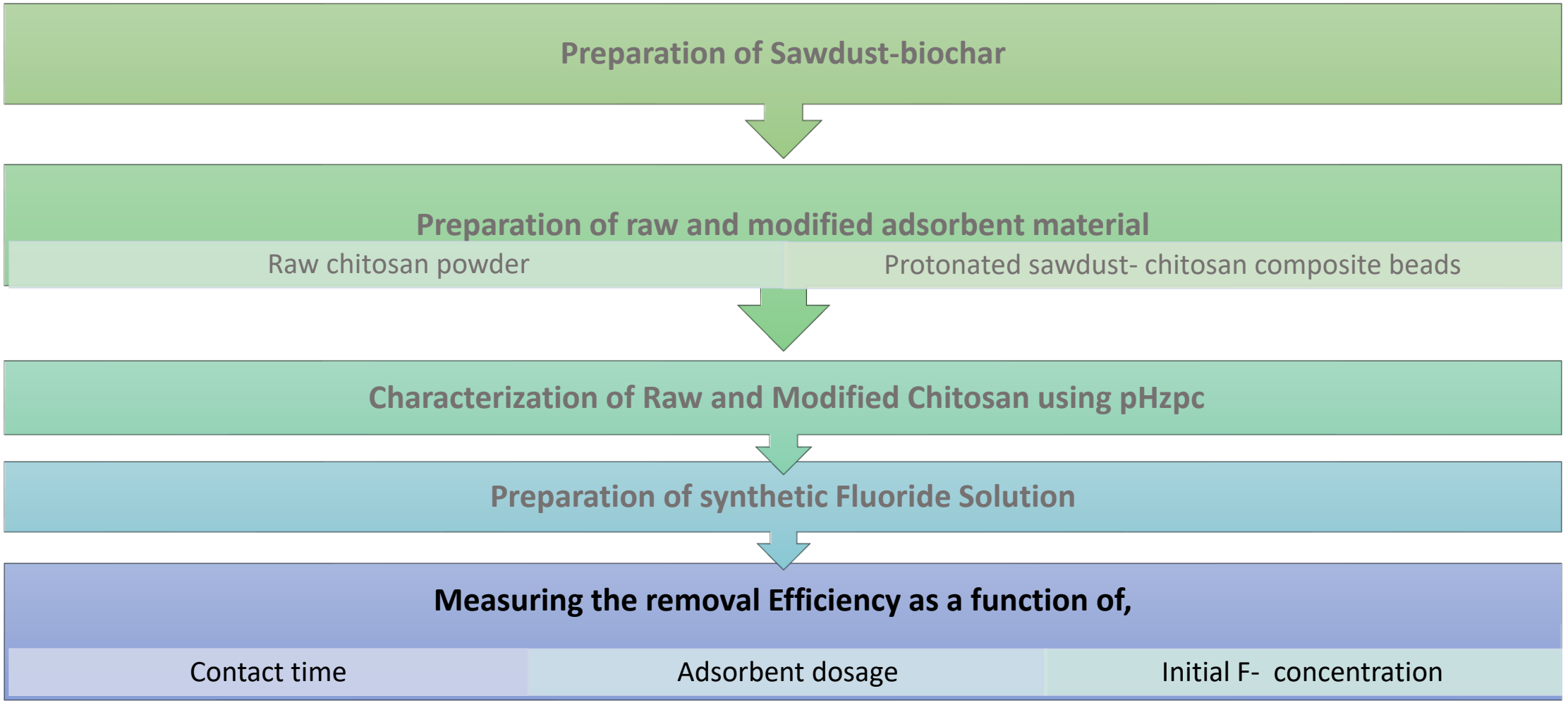
Sorption Experiments

- A Fluoride stock solution (100 mg/L) was prepared by dissolving 221 mg of anhydrous **sodium fluoride** (NaF) in 1 L of deionized water.
- All experiments were conducted at **room temperature** (25^0C).
- **Neutral pH** was maintained throughout the experiments.
- Fluoride concentration were measured by **SPANDS method** using a potable colorimeter.
- Batch experiments were conducted to study

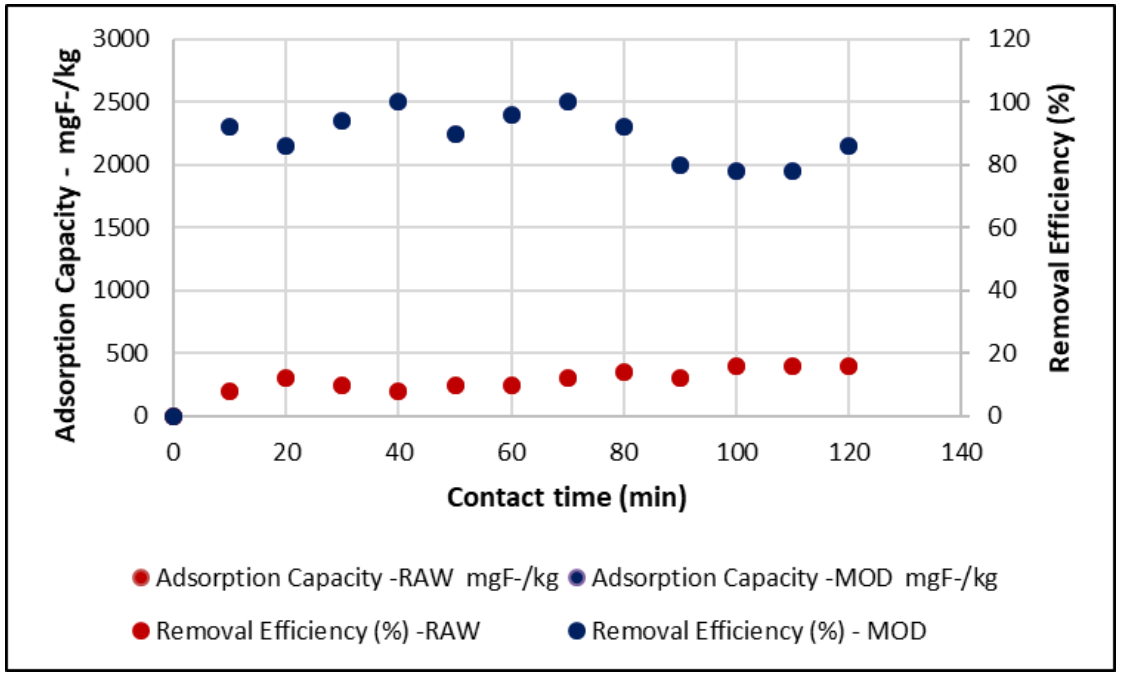
the effect of various influencing parameters like

- **Contact time,**
- **Adsorbent dosage**
- **Initial fluoride concentration**.

Methodology



Effect of Contact Time

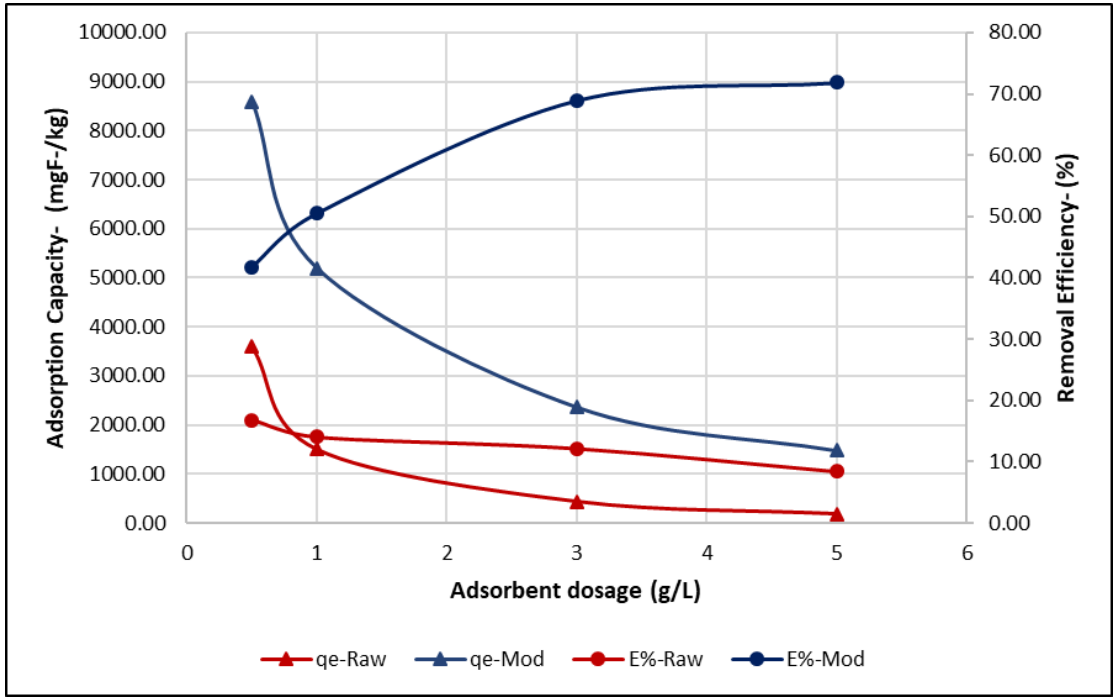


Adsorption of fluoride as a function of contact time

(Temperature = 25^{0}C; Initial fluoride concentration = 5 mg/L; Adsorbent dosage = 2g/l; pH = 7)

	Raw Adsorbent	Modified Adsorbent
Equilibrium time	120 min	60 min
Adsorption Capacity	400 mgF$^-$/kg	2500 mgF$^-$/kg
Removal Efficiency	16%	<90%

Effect of Adsorbent Dosage

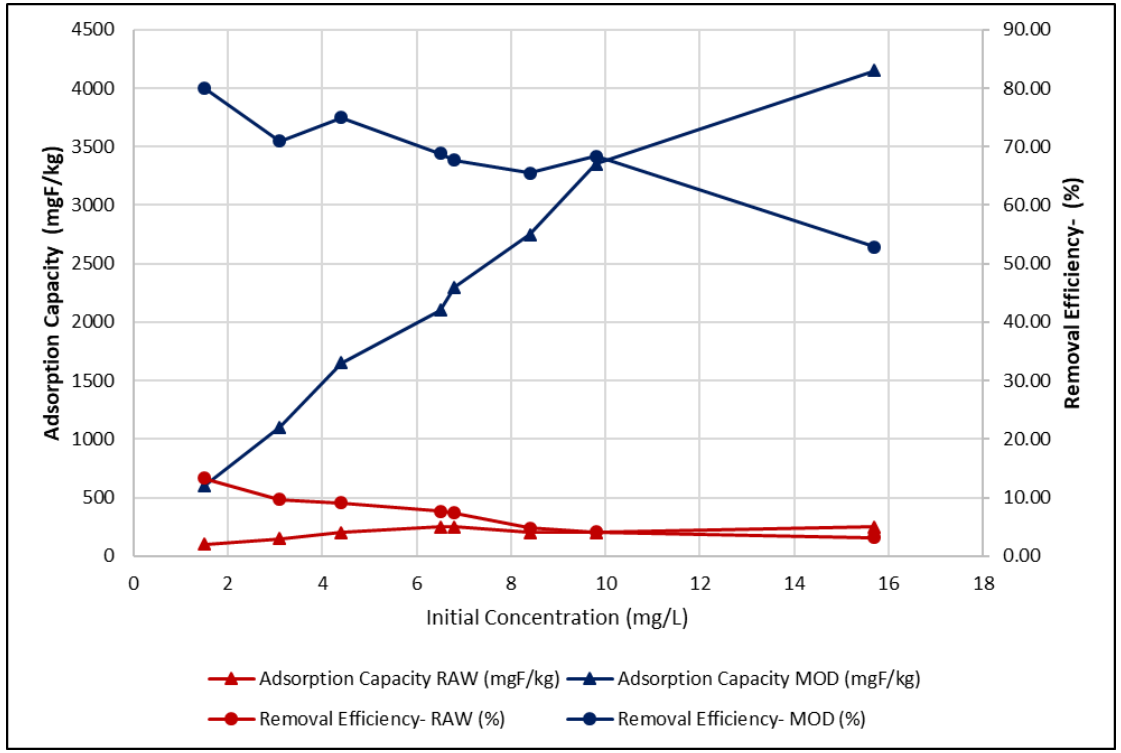


Adsorption of fluoride as a function of adsorbent dosage

(Temperature = 25^{0}C; Contact time = 60 min for Mod. Adsorbent and 120 min for Raw adsorbent; Initial fluoride concentration = 10 mg/l; pH = 7)

There is an increase in percentage removal of fluoride with increase of the dosage of adsorbent.	This could be due to availability of more active sites and larger surface area at higher dosage.
Fluoride removal efficiency decreases in raw chitosan at higher doses	There could be overlapping of active sites at higher doses which decreases the surface area.

Effect of Initial Fluoride concentration



Adsorption of fluoride as a function of initial fluoride concentration

(Temperature = 25^{0}C; Contact time = 60 min for Mod. Adsorbent and 120 min for Raw adsorbent; Adsorbent dosage = 2g/l; pH = 7)

Adsorption capacity of modified chitosan increases with increasing initial F- concentration.	Higher concentration gradients act as a driving force to overcome resistance between bulk solution and adsorbent surface.
With the increase in initial fluoride concentration, the percentage removal of fluoride decreases.	At higher adsorbate concentration, the binding capacity of the adsorbent approaches saturation, resulting in decrease of overall percent removal.

Conclusion

- Modified chitosan possesses an excellent defluoridation capacity compared to raw chitosan with **more than 90% fluoride removal** at equilibrium.
- The zero point charge of modified chitosan was found to be at **pH 2.2** hence it is **negatively charged** at pH 7.
- Higher adsorption capacity of modified adsorbent even at pH 7 could be attributed to **availability of surface complexities** rather than electrostatic attraction.
- Considering all the above facts, it could be said that Protonated Chitosan Biochar Composite beads can be used effectively for removal of fluoride from water.

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Acknowledgement

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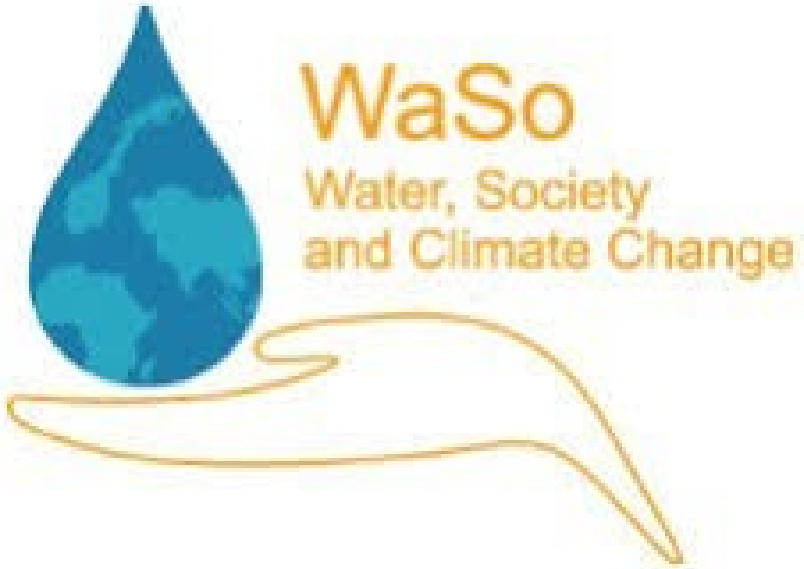

Thank you