APPLICATION OF LEAF BIOMASS HYDROCHAR AS A SUSTAINABLE METHOD FOR IMMOBILIZING HEAVY METALS IN CONTAMINATED SOILS

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Soil, Immobilization, Heavy metals, Heavy metal immobilization, Soil contamination, Soil remediation, Hydrochar, Adsorption, Metal ions, Leaf-based hydrochar, Sorption capacity.

Introduction:

Soil contamination with heavy metals is a growing concern over the past decade and mining is the major contributor to heavy metal contamination in soil among all the urban activities. Soil contamination with heavy metals leads to contamination of groundwater with heavy metals due to leaching. Nearly, 718 districts in India have contaminated groundwater with heavy metals. The Ministry of Environment, Forest and Climate Change (MoEF&CC) has identified 320 locations with high probability of contamination by heavy metals and pesticides in India. According to Narsimha Adimalla, 2019, higher concentration of Cr and Ni was in cities mainly located in southern (Karnataka), northern (Uttar Pradesh), and eastern (Odisha).

There is a deteriorating effect of heavy metal contamination on seed germination in agriculture as well. Heavy metals disrupt hydrolysing enzymes (acid phosphatases, proteases, and α-amylases) that play a crucial role in seed germination, which lead to immobilization of starch and hence, limited nutrient availability. Nickel (Ni) is a known carcinogen to humans. Effects of Ni exposure vary from skin irritation to damage of the nervous system. Nickel enters & accumulates in agricultural soils through the application of phosphate fertilizers, pesticides. Toxic level of Ni in soil limits the crop growth, reduces soil fertility, shoot growth, mitotic root tips enlargement, abnormal flower shape & drastic reduction in crop yield.

Several techniques have been developed to remediate the polluted soils, among which, stabilization/immobilization can rapidly change the properties of HMs and convert the contaminants into their less soluble, non-bioavailable toxic forms.
Pongamia pinnata is a deciduous tree that has been planted as a street tree and has a short dropping period in spring which litters the streets. Using the leaves of Pongamia pinnata leaves for production of synthesized leaf based hydrochar can

prove to be advantageous to help with the littering problem on the streets, reduced water and organic content ending up in landfills and also helps to improve soil quality by immobilization of heavy metals in the soil, avoiding their leaching.

Objectives:

1. To synthesize leaf based hydrochar using the leaves of Pongamia pinnata tree.
2. To characterize the synthesized hydrochar in order to assess composition of resulting hydrochar product.
3. To investigate the effect of hydrochar in immobilising heavy metals in contaminated soils.
4. To evaluate the potential application of synthesized hydrochar as a soil amending agent by conducting germination studies (GP, GE, GRI, MGT, VI)

Methodology:

Hydrochar is a low-cost, novel green carbon material derived from waste biomass by hydrothermal carbonization (HTC). In this process, biomass is subjected to elevated temperatures (usually between 180oC and 250oC) in the presence of water and sometimes a catalyst under pressure, typically ranging from 5-25 bars. In this project, Pongamia pinnata leaves are processed to produce a synthesized hydrochar & applied to chromium contaminated soil and the performance of the hydrochar is to be measured by conducting Germination studies & Biomass studies. The effect of hydrochar on plant uptake is measured by AAS studies.

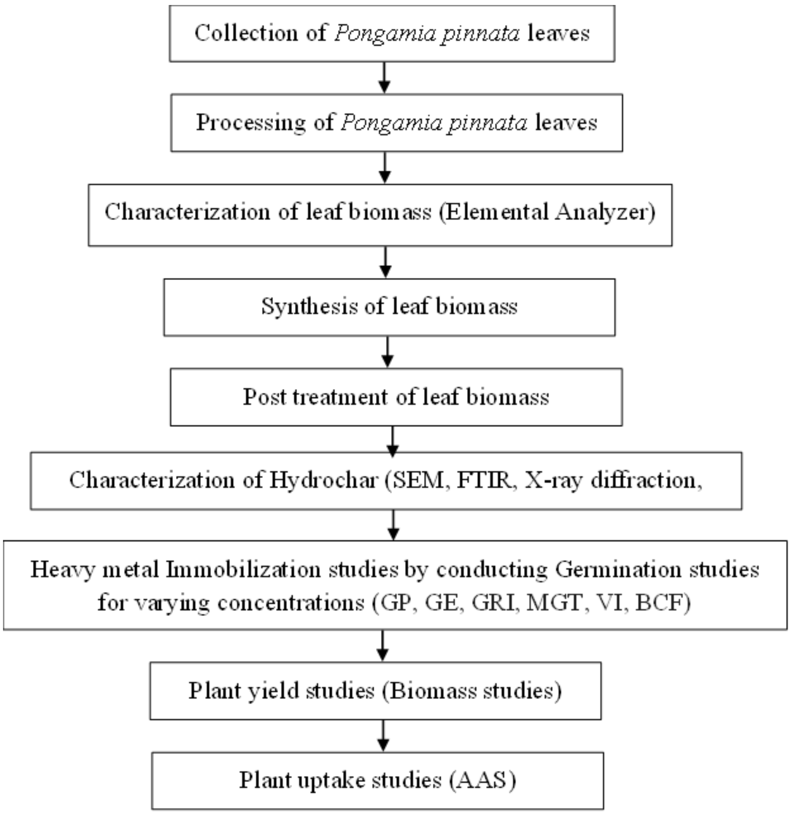


Figure1: Flowsheet of methodology of project

- Preparation of soil-
  - ➢ Particle size distribution of raw red soil:

2kg of raw red soil was sieved

↓

The soil passing through 2mm sieve to the pan were collected

↓

The soil retained on each pan was weighed and weight was noted in Kg

↓

The graph of Sieve size vs soil retained on sieve was plotted

↓

The soil sample is collected and mixed well to obtain homogeneity

Figure 2 Flowsheet of particle size distribution of raw soil

- ➢ Preparation of heavy metal spiked soil:

- **<u>Measurement of pH of soil sample - Electrometric method-</u>**

Sieve the soil sample through 425-micron sieve

↓

Collect the sample passing through 425-micron sieve

↓

Measure 30g of soil sample and mix with 75ml of distilled water

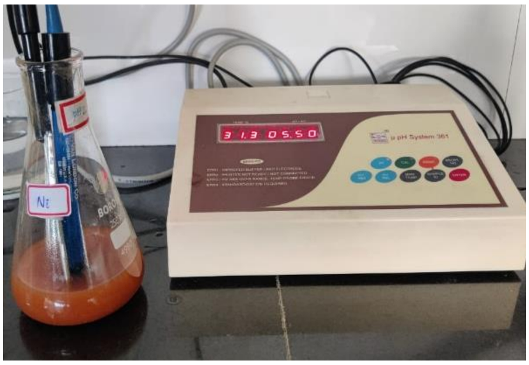
↓

Cover the beaker and leave for 1 hr

↓

Mix well and measure pH using pH meter

Figure3: Flowsheet of measurement of pH of soil sample- Electrometric method

- **<u>Measurement of electrical conductivity of soil sample-</u>**

Weigh 20g of soil sample

↓

Mix with 40ml of distilled water

↓

Place the sample in shaker incubator for 30mins

↓

Measure electrical conductivity using conductivity

- **<u>Measurement of organic matter in soil sample by Loss on ignition method-</u>**

Sieve the soil sample and collect the soil passing through 2mm sieve

↓

Weigh the empty crucible (W1)

↓

Take 5g of soil sample and oven dry at 105°C overnight

↓

Estimate the moisture content

↓

Place oven dried sample in muffle furnace @500°C for 2-3hrs

↓

Estimate organic matter in %

Figure4: Flowsheet of measurement of organic matter in soil sample by Loss on ignition method

<u>Calculations:</u>

% Moisture content = ((W2-W3)/W3) x 100

Where, W1=Weight of empty crucible

W2= Weight of wet soil sample

W3=Weight of oven dried sample

%Organic matter = ((W3-W4)/W3)) x 100

Where, W4= Weight of soil sample after ignition

- **TCLP-**

1g of dried soil sample passing through 2mm sieve is collected

↓

20ml of TCLP extraction fluid is added

↓

Continuously agitated for 18hrs at 100rpm

↓

Solid and supernatant are separated using membrane filter or centrifuge

↓

Metal concentration is checked in supernatant using AAS

Figure5: Flowsheet of measurement of TCLP of soil sample

pH was checked and was found to be <5, hence extraction fluid 1 was used.

➢ **Preparation of extraction fluid 1:**

Add 5.7ml glacial Propionic acid (CH3CH2OOH)

↓

Add 64.3ml of 1N NaOH and dilute to 1000ml with distilled water

↓

Check pH. pH must be around 4.93+0.05

Figure6: Flowsheet of preparation of extraction fluid 1

- <u>**Synthesis of leaf based hydrochar-**</u>

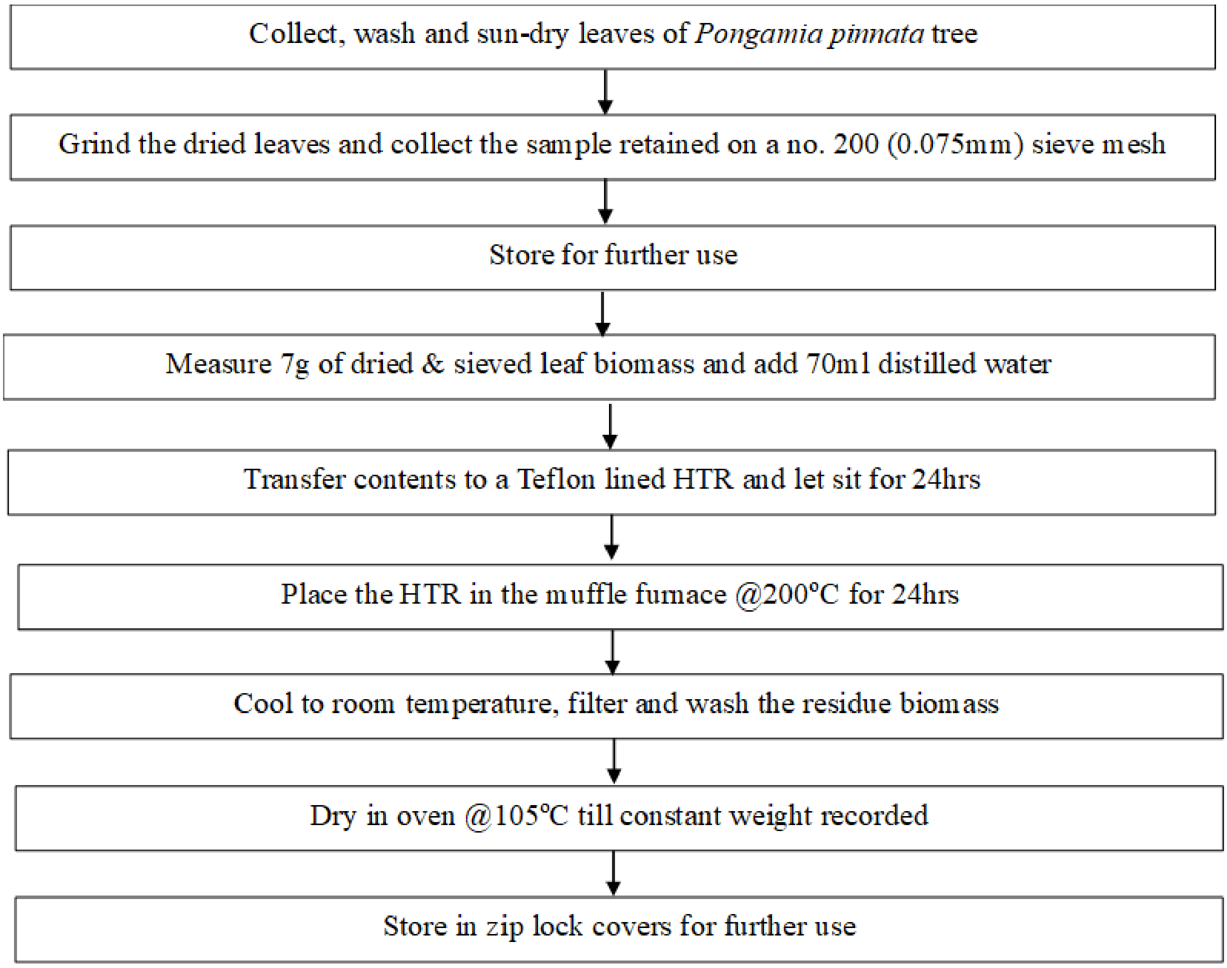


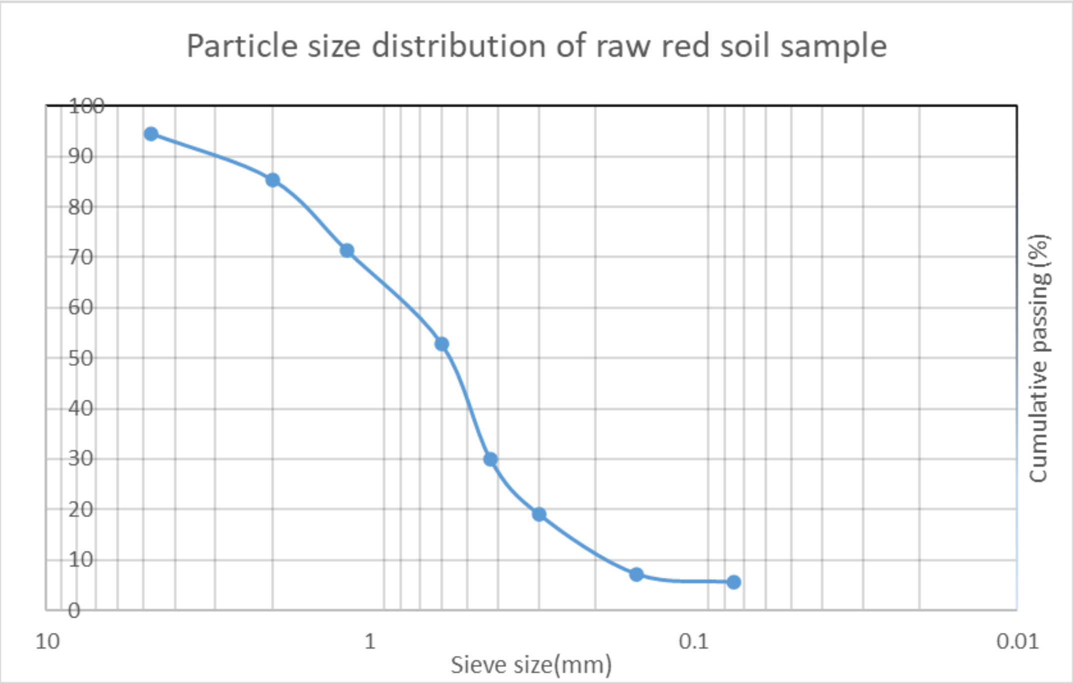
Figure7: Flowsheet of synthesis of hydrochar

The hydrochar is post-treated with 10% H_2O_2:

Results and conclusions:

➢ Particle size distribution: The graph plotted is an inverted logarithmic graph in order to represent the particle size distribution of soil sample.

Sieve size	Weight retained (kg)	%Weight retained	Cumulative weight retained	Cumulative passing (%)
4.75	0.054	5.4	5.4	94.6
2	0.092	9.2	14.6	85.4
1.18	0.14	14	28.6	71.4
0.6	0.186	18.6	47.2	52.8
0.425	0.228	22.8	70	30
0.3	0.11	11	81	19
0.15	0.118	11.8	92.8	7.2
0.075	0.016	1.6	94.4	5.6
Pan	0.056	5.6	100	0
Total	1			



- The pH of raw red soil sample was found to be 6.44 and that of the Ni spiked soil sample was found to be 5.5.
- The electrical conductivity of the raw soil sample was found to be 0.702 and that of the Ni spiked soil sample was found to be 0.726.
- Moisture content of soil:

1. Moisture content in raw soil

W1RS= 15.88g
W2RS=5g
W3RS= (20.77g-15.88g) =4.89g
MCRS= ((5g-4.89g)/4.89g) x100=2.25%

2. Moisture content in Ni spiked soil

W1Ni= 18.092g
W2Ni=5g
W3Ni= (20.77g-15.883g) =4.89g
MCNi=((5g-4.788g)/4.788g)) x 100=4.43%

- The TCLP value of the Ni spiked soil was found to be 11mg/kg.

(0.678mg/l x 0.017)/1g
=0.011mg/g x 1000
=11mg/kg

- Hydrochar yield obtained:

Empty crucible weight = 75.6809g
Empty crucible weight + Oven dried hydrochar = 82.8909g
Hydrochar obtained = (82.8909-76.809) = 7.2g

Innovation in the project:

Pongamia pinnata leaves have been used as the hydrochar material which has been less explored for the purpose of hydrochar preparation for heavy metal immobilization in soil. Pongamia pinnata is a deciduous tree that has been planted as a street tree and has a short dropping period in spring which litters the streets.
Using the leaves of Pongamia pinnata leaves for production of synthesized leaf based hydrochar can prove to be advantageous to help with the littering problem on the streets, reduced water and organic content ending up in landfills and also helps to improve soil quality by immobilization of heavy metals in the soil, avoiding their leaching.

Current status of project work:

The experiments are still in progress and the experiments to be conducted are mentioned below:

1. Conducting sequential extraction procedure (SEP) to investigate the effect of synthesized, H¬2O2 post-modified leaf based hydrochar in immobilising heavy metals in heavy metal spiked soil.
2. Performing Germination studies in order to evaluate the effect of application of the synthesized & H2O2 post-modified hydrochar on germination of seeds.
3. Evaluating the efficiency of application of the synthesized hydrochar on heavy metal spiked soil by measuring plant yield through biomass studies and plant uptake studies.

Conclusion:

In this work, we presented a simple, yet effective folding system for quadrotors that consists of four arms that can fold around the main body. Our approach does not require symmetries in the morphology to guarantee stable flight. We showed that simple folding mechanisms combined with adaptive control strategies are a viable solution to broaden the spectrum of applications of quadrotors. This could lead to a formal shift in the research community towards novel folding aerial vehicles. However, there are still a number of unsolved research questions, such as automatic folding selection, exploitation of the morphology for improved flight at high-speed, and novel, bio-inspired mechanical designs

Scope for future work:

1. Flight through narrow gaps: Previous works addressing quadrotor flight through narrow gaps have shown at an aggressive maneuver is required to align the vehicle with the gaps orientation to avoid collisions. Flight through arbitrarily shaped gaps using monocular vision has also been shown. In all those works, the gap has be large enough to let the vehicle pass through

2. Close proximity surface Inspection: The supplementary images shows the results of an experiment highlighting the benefits of the T configuration against X morphology for surface inspection

3. Object Grasping and Transportation: The drone can close its arms around objects to grasp and transport them. Although this strategy cannot replace specialized and effector.

Reference:

1. U.K. Shanwad, V.C. Patil, G. S. Dasog, C.P. Mansur and K. C.Shashidhar Department of Agronomy, University of Agricultural Sciences Dharwad - 580 005. Karnataka. {*shanwad@rediffmail.com*}.

2. The Foldable Drone: A Morphing Quadrotor that can Squeeze and Fly.

3. D. Falanga, K. Kleber, S. Mintchev, D. Floreano and D. Scaramuzza.