BEFWAM: Bioenergy, Fertiliser and Clean Water from Invasive Aquatic Macrophytes

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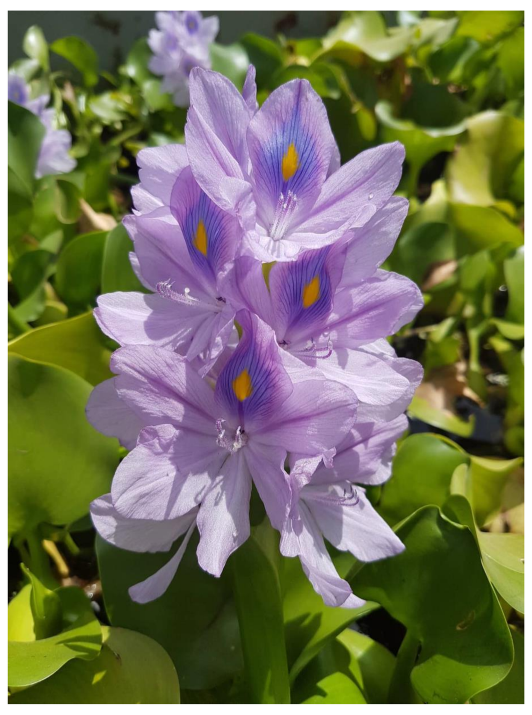


SAMPLING & CHARACTERISATION

Representative samples of water hyacinth and other invasive macrophytes are required to perform anaerobic digestion tests at both laboratory and full scale. An assessment of the variation in the composition of the biomass is assessed as part of **WP1 (Anaerobic conversion of invasive macrophytes)**.

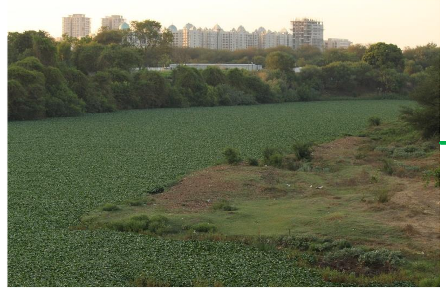
Homogenised samples of Water Hyacinth will be collected from Uganda and India and a detailed characterisation will be performed including biochemical composition, proximate and ultimate analysis and inorganic content.

The samples will be utilised in **WP1 (Anaerobic conversion of invasive macrophytes)** to assess suitable pre-treatment and single stage anaerobic digestion and in **WP2 (Investigating routes to enhance methane yields and biogas quality)** for assessment of upgrading strategies.

In addition to samples of invasive biomass, a selection of indigenous biomass, suitable for the production of biochar will be collected and analysed as part of WP1 for utilisation in **WP3 (Development of immobilized bioreactors systems).**

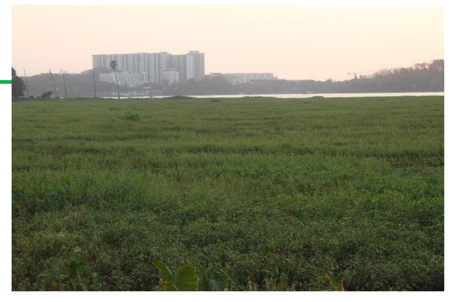
SAMPLING SITES

Indryani River
Industrial/Sewage Pollution

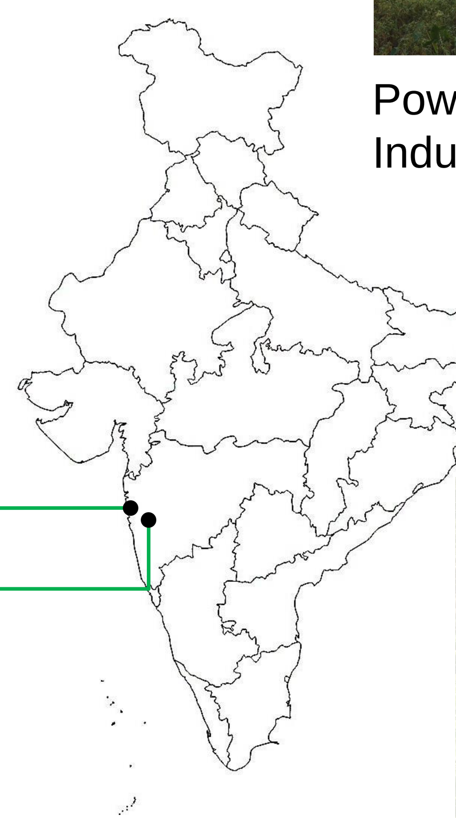


Mula Mudtha River
Sewage Pollution

Pawana River
Sewage Pollution



Powai Lake and Mithi River
Industrial/Sewage Pollution



Sampling sites in India

Goyal Para
Nutrient Rich Pollution

Three sampling sites have been identified in India and Uganda, representing (i) nutrient rich, (ii) Sewage pollution and (iii) Industrial/sewage pollution.

Samples were collected throughout the year (Autumn/Monson, Winter, Spring and Summer) to assess the seasonal variation in composition and suitability towards conversion.

MORPHOLOGY

Leaf
Average of 6-8 leaves per plant, forming a spiral phyllotaxy. Young leaves form at the centre of the rosette.

Petiole
Often form swollen floats. Vary in length depending on local conditions (1-2cm up to 1m).

Root
Main fibrous roots surrounded by feathery hairs to increase surface area.

Stolon
Daughter plants are produced via clonal propagation. The stolon is more anatomically similar to the stem than petiole.

Inflorescence
The lilac flowers develop on a terminal inflorescence that has between 4 and 25 flowers, depending on the size of the plant.

Stem
The stem is visible up to 2 weeks before flowering. The flower wilts and the stem bends towards the water via elongation of epidermal and hypodermal cells.

Flower
The flower has a short life cycle, ~48 hours in peak summer. Rising in the morning and wilting at night before the fruit develops.

COMPOSITION OF WATER HYACINTH

Parameter	Content (%)
Lipid	6.8-10.5
Protein	10.3-20.0
Fibre	18.6-59.2
Fat	2.3-8.3
Lignin	3.2-26.4
Cellulose	18.0-31.0
Hemicellulose	18.4-43.4
Nitrogen	1.2-2.9
Phosphorous	2.4-4.5
Ash	11.4-38.1

The composition of water hyacinth in the literature shows significant variation and is dependent upon sampling location, environmental conditions and harvesting time.

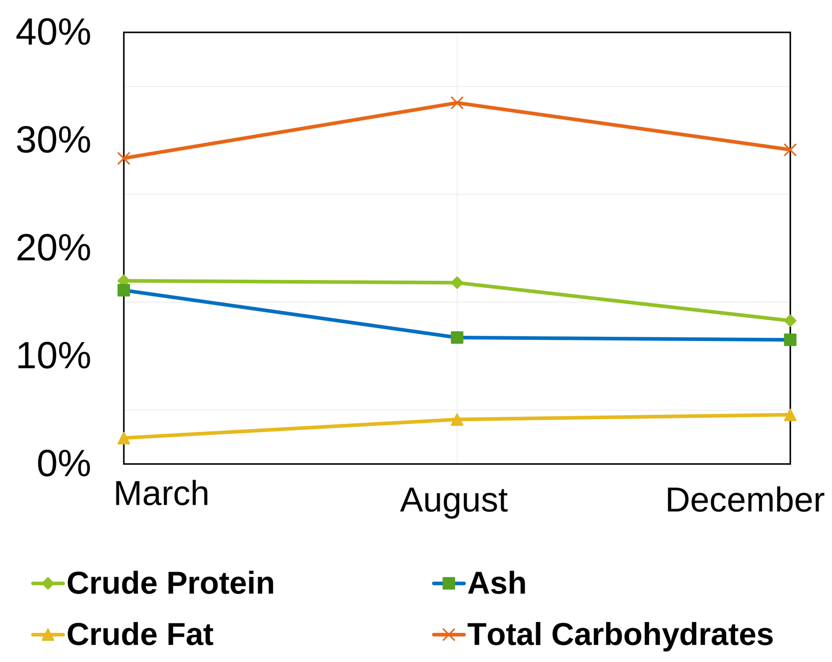
This results in large variations of key parameters including biochemical content, yield and levels of contamination.

The Seasonal variation in biochemical content is illustrated in the figure below and indicates the highest carbohydrate content in the summer.

The literature however shows significant variation and in some cases, conflicting results.

The detailed sampling programme underway as part of the BEFWAM project will provide a more complete data set of biomass composition.

An assessment of the genetic variation of biomass samples in India and Uganda will be performed in collaboration with Kew.



References: Shanab *et al.* (2015) *Waste and Biomass Valorization* **9**(2); Das *et al.* (2016) *Biotech.* ***6****(1); Abdel Shafey et al. (2016) Egyptian Journal of Chemistry* **59**(2); Guna *et al.* (2017) *ACS Sustainable Chemistry & Engineering* **5**(6); Mako *et al.* (2011) *Livestock Research for Rural Development* **23**(5); Gunnarsson and Petersen (2007) *Waste Management* **27**(1); Kaur *et al.* (2018) *Bioresource Technology* **251**.

ARTIFICIAL CULTIVATION

Artificial cultivation of water hyacinth in tanks has been developed in Pune, India (Defiant renewables).

The plants were collected from Pawana River, Pune and cultivated in either tap or river water, with both displaying steady growth to the saturation point.

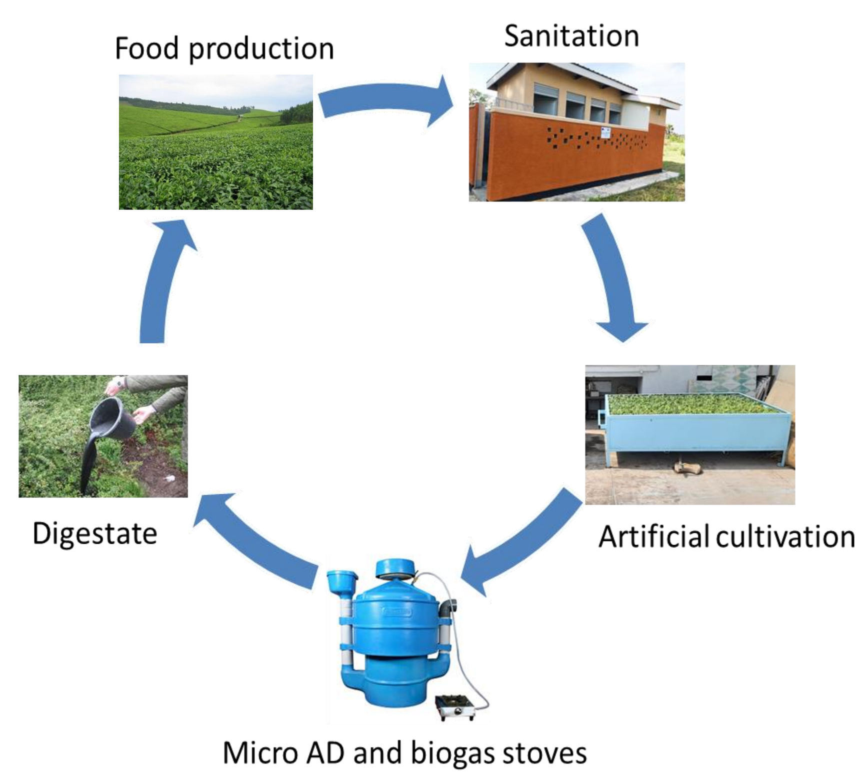
Future studies include the effect of water flow, nutrient levels, clone varieties and growth cycle on biochemical composition.

Artificial cultivation will be investigated using whole plants and seed water.

Expertise in cultivation techniques developed in India will be transferred to Uganda via exchange programmes

Cultivation will be investigated using different nutrient sources including animal and human waste.

Cyclic approaches linking sanitation, AD and fertiliser will be investigated.



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