Exploiting intermittent feeding strategy for improved dark - colored poultry litter management and bioproduct recovery : Microalgae based approach

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With increasing focus of the global community towards sustainable development goals (SDGs) and circular economy in agriculture and livestock industry, several scientific and industrial clusters have directed their interest to eco-friendly waste(water) management and resource recovery platforms. For example, the rapid expansion and exceeding density of need for poultry farming generated voluminous quantities of poultry litter and wastewaters (PLW). PLW primarily consists of organic and inorganic nutrients, heavy metals and other deleterious residues. If left untreated it can cause environmental complications [1]. Legitimate, sustainable and promising techniques offer effective disposal and resource extraction [2]. Biological process like microalgal system can potentially utilize these nutrients and heavy metals as a substrate and concomitantly recover value-added products. However, the dark color of PLW poses a serious challenge for light penetration which is crucial for microalgal biocatalysis.

OBJECTIVES

- Studying the suitability of dark-colored PLW as a substrate for *Chlorococcum infunsium* cultivation at different concentrations
- Investigating a new feeding strategy to

1. overcome light penetration and substrate inhibition issues
2. enhance biomass productivity and optimize the yield

- Improving the microalgal biocatalysis for PLW treatment and bioproduct (lipid and carbohydrate) recovery

MATERIALS & METHODS

- Poultry litter : Collected from local poultry farm (Kharagpur, India)
- Microalgae : *Chlorococcum infusionum*
- Cultivation : Mixo(heterotrophic) with PLW as media
- Feed strategy : Single feed (SF) and intermittent feed (IF)
- Conditions : White light 50µmol/s/m^2, 14:10h (L/D) & 26 – 28 °C
- Operation : Batch mode (SF) and Fed-batch (IF)

Table 1 : Nutrient characterization of solid and soluble poultry litter (mg/L)

SOLID POULTRY LITTER : MACRO & MICRO NUTRIENTS				
Ca	**K**	**Mg**	**Na**	**P**
15	31	1.75	3.16	19
Cr	**Cu**	**Zn**	**Fe**	**Mn**
104	193	253	18	0.99
SOLUBLE POULTRY LITTER (per1g/L PLW)				
NH_4^+	**NO_3^-**	**NO_2^-**	**PO_4^{3-}**	**TOC**
25	4.05	0.32	24	19

- Solid and soluble PL were analyzed with XRD – MS, ICP and standard colorimetric techniques (Table 1)
- PLW (1 - 20 g/L) was used as substrate for microlgal growth in 150ml conical flasks during SF experiments
- Better performing PLW (7.5 - 20 g/L) were used as substrate by spiking with PLW in definite steps during IF experiments
- Feeding time intervals used : 3, 5 and 7 day (Fig 1)

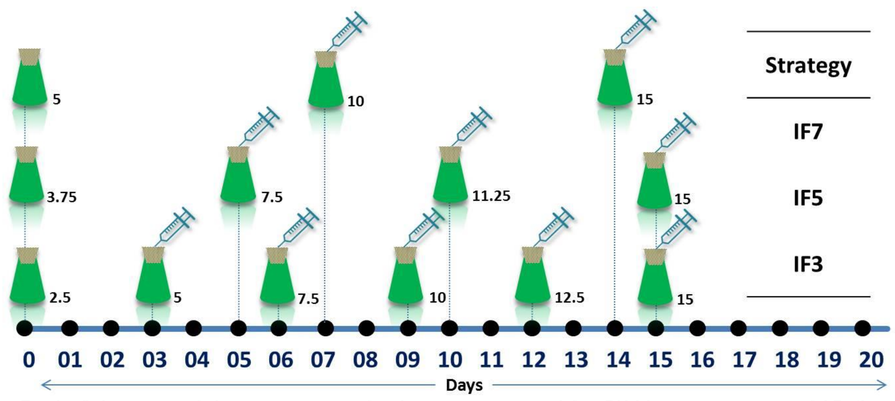
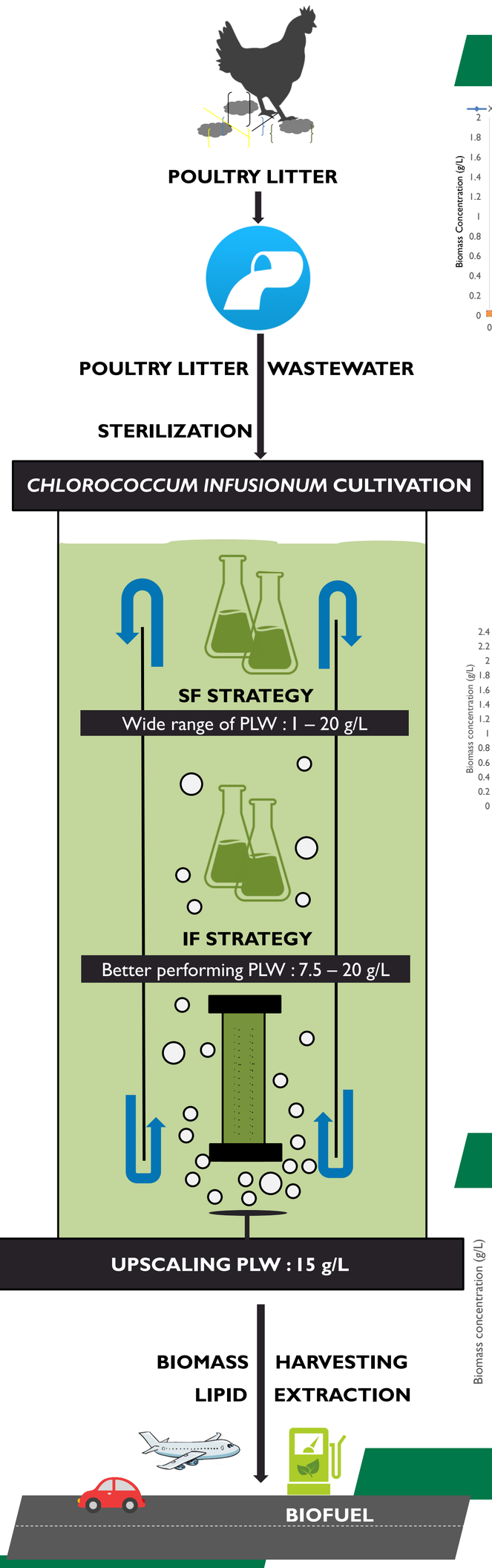


Fig 1 : Schematic of the intermittent feeding strategy used for PLW concentration of 15g/L

- Upscaling study was performed for best performing PLW concentration in a 1.5-litre photobioreactor (PBR)
- IF strategy used : IF3 (3-day interval)

CONCLUSIONS

- Poultry litter is a promising and potential waste-to-energy source using *C. infusionum*
- Nutrients supplied at regular interval during IF strategy showed enhancing and positive effect on the biomass yield and productivity
- PLW concentration of 15g/L is optimum for better biomass yield with optimized feeding strategy of 4-time feed (3 spikes)
- Lipid and carbohydrate content for value-added product recovery was found to be 15 - 20% and 30 - 35% (w/w)
- Further optimization of light and flow rates is required for scale-up activities



MAIN RESULTS

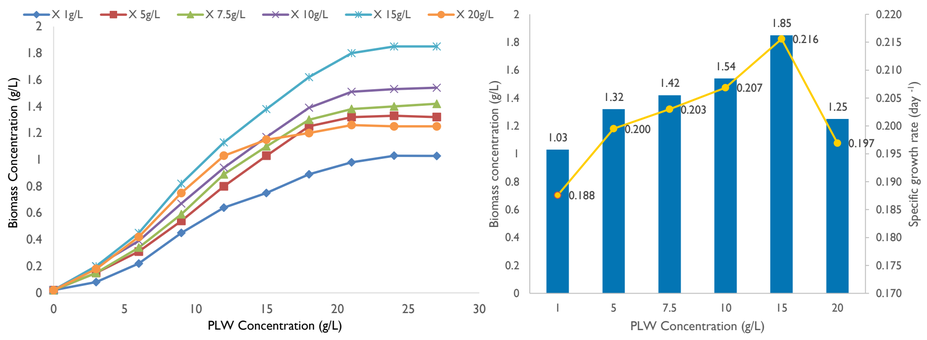


Fig 2 : (L)The profile of microalgal growth over 27 days and (R) end biomass concentration with specific growth rates at different PLW concentrations in conical flasks (50 ml working volume) during SF strategy

- The microalgal biomass productivity ranged between 38.15 to 68.52 mg/L/day with PLW 15g/L producing the maximum yield in SF strategy (Fig 2)
- The specific growth rate (µ) was observed to be maximum in PLW 15g/L with value of 0.216 day^{-1}
- Doubling time of *Chlorococcum sp.* in all PLW concentrations averaged at 3.45 days with deviation of 4.7%

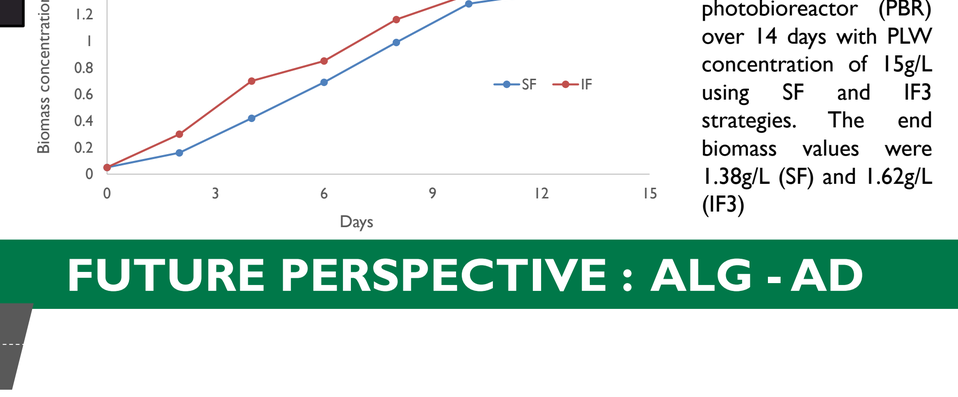


Fig 3 : (L)The profile of microalgal growth over 27 days (IF7) (R) and end biomass concentration of best performing different PLW concentrations (10g/L & 15 g/L) in conical flasks (50 ml working volume) during intermittent feed (IF3, IF5 & IF7) strategies

- In IF7 strategy, weekly pulsating of PLW neutralized the initial inhibitory effect and allowed better light penetration resulting in 2.1 g/L of biomass yield for 15 g/L (Fig 3)
- IF3 and IF5 strategies in the multi-feed experiments maximized the yield up to 2.3 g/L and 2.5 g/L respectively
- Pulsating substrate at a time gap (3 or 5 days) close to doubling time boosted the growth of microalgae

UPSCALING STUDY

Fig 4 : The profiles of biomass growth in 1.5-litre airlift photobioreactor (PBR) over 14 days with PLW concentration of 15g/L using SF and IF3 strategies. The end biomass values were 1.38g/L (SF) and 1.62g/L (IF3)

FUTURE PERSPECTIVE : ALG - AD

- The corresponding author will make use of the experience gained (during this study) at Indian Institute of Technology in Kharagpur for his ongoing research at UGent, within the framework of the European **ALG-AD** project
- In **ALG-AD**, a pilot reactor will be constructed to cultivate algal biomass on nutrient-rich solutions recovered from biogas digestate (dark-colored stream)
- The fabricated reactor will be operated in Flanders (Belgium) and further researched for potential algal protein production that could serve to substitute currently imported protein for animal feed production

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[2] Karemore, A., & Sen, R. (2015) RSC Adv,ances 5(87)

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