Valorization and Management of Biogas Slurry

By

Satyawati Sharma

At

Int. Workshop on "Promotion of Biogas Upgrading and Bottling in India and European Union" on August 22 - 24, 2013 ,

IIT Delhi

Introduction

- No. of Biogas plants (BGFP) installed in India= 4.31 million (household and community type)(MNRE,2013)
- Of these 95.81% functional.
- Huge quantity of BGS is being produced
- BGS = A byproduct produced during biogas production
- BGS is good O.M (free from weed seeds and pathogens, nutrient rich)

- But due to high water content ;

  92-94% in cattle dung based BGS

  97-98% in food waste BGS , not being utilized optimally.

- Transportation/ storage biggest problem.
- Sun drying –common method ,nutrients (N,S etc.) lost.
- Other applications of BGS: As biopesticide (Aphid, Beetel) pisciculture, animal feed (pig), dye absorption, mushroom cultivation (only *Pleurotus*) **(Some references)**

✓ **Not much field work has not been done**

Objectives (MNRE sponsored project)

1. Technological interventions for enrichment of BGS during dehydration and packaging operations.

2. Development of protocols for utilization of BGS in liquid (algal biomass production), semi solid (vermi compost), and solid form (mushroom & organic manure).

3. Integration of protocols for developing the entrepreneurship package (Integrated Approach).

1.Characterization of BGS

Characteristics of Fresh, Sundried and One month stored slurry

Parameters tested	BGS from Purana Farm House,Vasant kunj, N.Delhi		
	Fresh	Sundried *	Stored for one month
Cellulose (%)	29.44	28.75	20.75
[illegible]	[illegible]	[illegible]	[illegible]
C % (dry wt. basis)	37.25	38.5	16.99

✓ ***~18.18% N lost during sun drying ,Also*** **time consuming process**

✓ ***~9% N loss in storage for one month***

✓ ***Also lot space in both the cases needed***

•1 inch thick layer of Slurry dried for 1 month

Nitrogen (TKN): 0.88% , Nitrate: 0.08% , Ammonical N: 0.07%

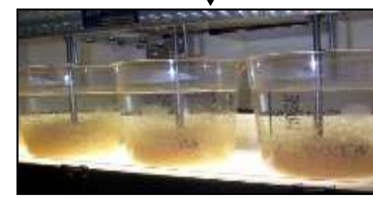
2. Dehydration of BGS

Methods BGS Dehydration

Centrifugation

Sun drying

Filtration



Coagulation

Mechanical

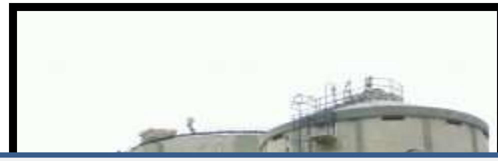
Vibration motion filtration

Screen filters

Screw press

Drum filters

Glimpses of Visit to PEDA installed / DSM operated Biogas Plant , Ludhiana, Punjab



✓Liquid fraction with 3% solids

✓Nutrient distribution

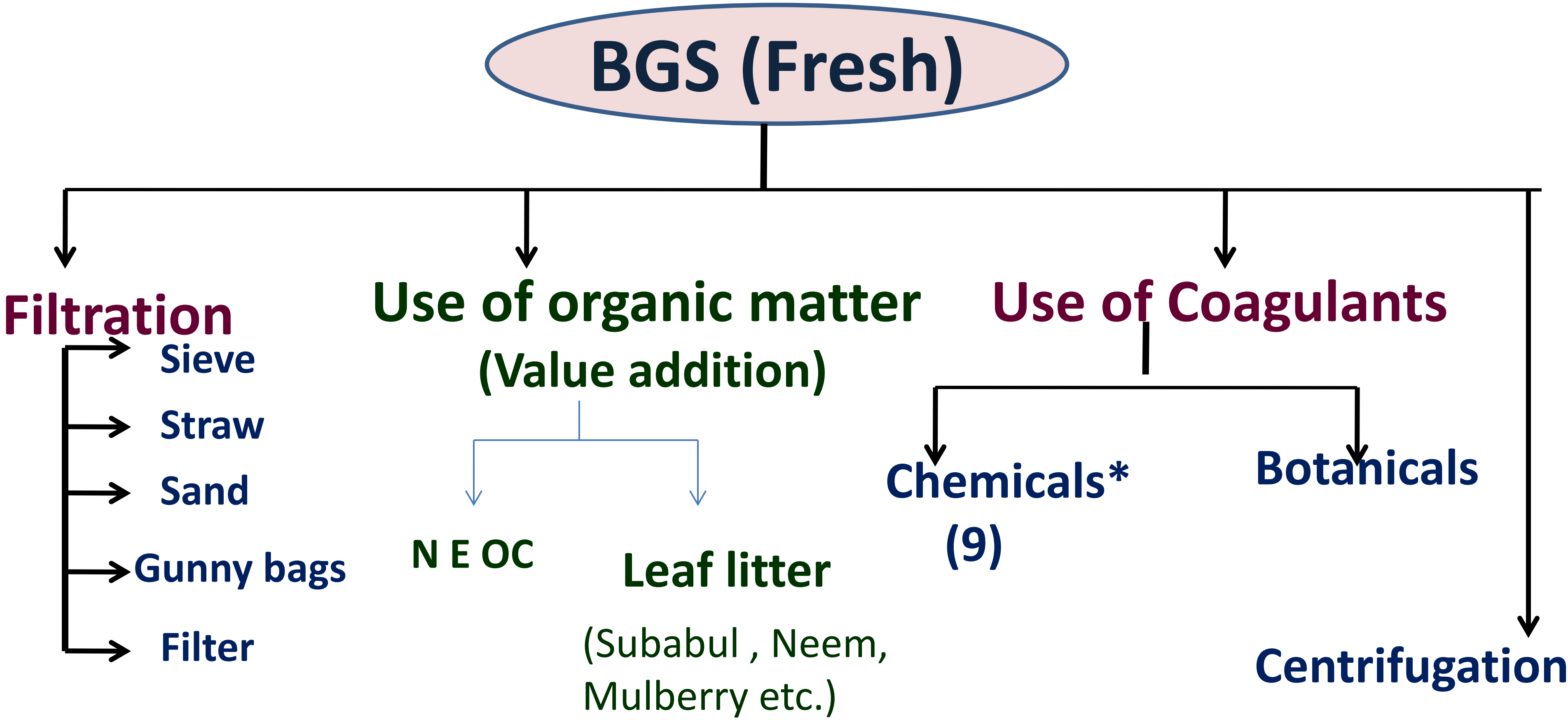
PI and CO-

achin

Solid and dried slurry separator

Vibration filtration unit at PAU, Ludhiana

Methods Tested for BGS Dehydration



*Alum (with and without KOH,KCL), Iontosorb oxin, Polyhydroxamic acid (PHA), Polyacrylamide, Acrylamide, Gelatine, Epichlorohydrin, Chetosan, DMA

Filtration of Slurry

Non-filtered (raw)
Bi…

Filtration of slurry by **sieve**

Collection of solid residue

- ✓Time consuming process **(mechanization needed)**
- ✓**Nutrients are distributed** in both the fractions
  - N – More or less equal in solid and liquid
  - P & K - more in Solid residue than in liquid
- ✓Research on **removal of nutrients from liquid** fraction needed.

Filtration of slurry by using **sand** (1 inch)

Filtration of slurry using **wheat straw**

Slurry (solid residue)

Filtration by Gunny Bags

Fresh/Raw BGS

Gunny Bag Filtration Set-Up
At Micron

Water Obtained
(~50 %)

Properties of removed water

EC: 5.83mS/cm , pH: 8.6, NTU: 812

Further work needed

Coagulation: Strategy followed

BGS

Chemicals

Iontosorb oxin, Polyhydroxamic acid (PHA), Polyacrylamide, Acrylamide, Gelatine, Epichlorohydrin, Chetosan, DMA **(9)**

Tested at various **concentrations,** different **rpm** and **time** period

No encouraging results

Optimization*

Alum

✓3.6% alum removed 40% H_2O with 298 NTU in 4 hr

***Optimization** (Homogenizer) :

Speed and time of Flash mixing & stirring ,
Quantity of alum

Botanicals

Cactus

No results

Moringa

Optimization

✓15gm/l (1.5%)removed 30% liquid(H_2O) with 350 NTU in 24 Hr.

Alum Dose Reduction

↓

Using **Chemicals** *(KCl, KOH),*

Polyelectrolytes

(*Polyacrylamide, Chitosan,*

Epichlorohydrin, DMA)

↓

Best results with **2% alum** *and* **Dimethylamine (44% water removal with** EC: 13.9 mS/cm; **pH: 4.97 and NTU 242)**

Characteristics of water and Sludge separated by Moringa (15g/L)

Parameter	Water	Sludge
EC (mS/cm)	1.4	8.3
pH	7.5	7.05
TOC (%)	15.8	64.5
N (%)	0.9	2.82
P%	0.5	1.51
K%	0.57	1.01

- ✓ **Quantity of water removed = 30% with 350NTU**
- ✓ **Enriched sludge/solid fraction(**Protein in moringa seeds= 61%)

Centrifugation of BGS- Optimization –>Removed 65% water with 1700 NTU

(BGS NTU: 857 in 100 times dilution)

7500 RPM for 10 min (Optimized)

Treatment of water
To reduce turbidity

Alum

~94%turbidity removal with alum (1.25%)

Moringa

~94% turbidity removal with Moringa (10g/L or 1%)

Value addition of BGS using Non Edible Oil Cakes

BGS

Neem Cake | **Jatropha Cake** | **Karanja Cake** | **Mahua Cake**

Optimization of quantity of cakes

60% BGS + 40% cakes (w/w) produced best results pertaining to microbial (detorioting) free product

Analyzed the product for EC, pH, N, P, K and C

Evaluation of shelf life of the product

Properties of Value Added BGS (With NEOC)

Sample	EC (mS/cm)	pH	TOC%	TKN%	C:N	%K	%P
Biogas Slurry	4.98	7.9	37.69	0.75	50.25	0.8	0.43
Mahua Cake	2.58	5.8	44.20	2.04	21.66	1.10	0.60
Mahua cake + BGS (6:4)	3.71	6.39	40.78	**1.86**	21.92	**1.08**	**0.56**
Karanja Cake							0.90
Karana cake + (6:4)							**1.38**
Neem Cake							1.1
Neem cake + B (6:4)							**1.38**
Jatropa	2.41	6.01	44.35	5.03	7.35	1.2	1.41
Jatropha cake +BGS (6:4)	3.67	6.82	41.15	**3.56**	9.02	**2.43**	**1.61**

- ✓NPK content increased significantly
- ✓Work on optimum doses for different crops (seed germination)required

Value Addition of BGS through Algae cultivation

(A) *Azolla*

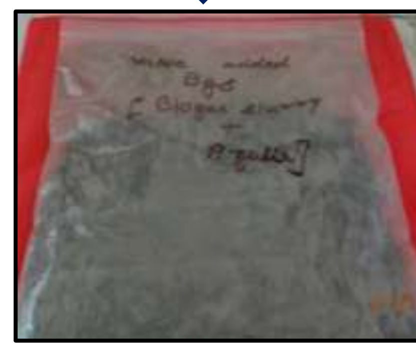
BGS + Azolla

BGS (5 Kg)+ *Azolla* (0.70 Kg, **Optimized**)
(Total weight 5.7 Kg)

↓ Grown for **20 days** with maintained **pH**

Quantity obtained : 6.9 Kg (Moisture content = 62.5%)

↓ Oven dried



Dried value added product

Dried product

C (%) = 30.21

N (%) = 1.88
P (%) = 1.23
K (%) = 0.99

← ✓**Increased significantly from initial value (N= 0.88%; P= 0.58%; K= 0.87%)**

(B) *Chlorella*

BGS (1 L)+ Organic amendments +

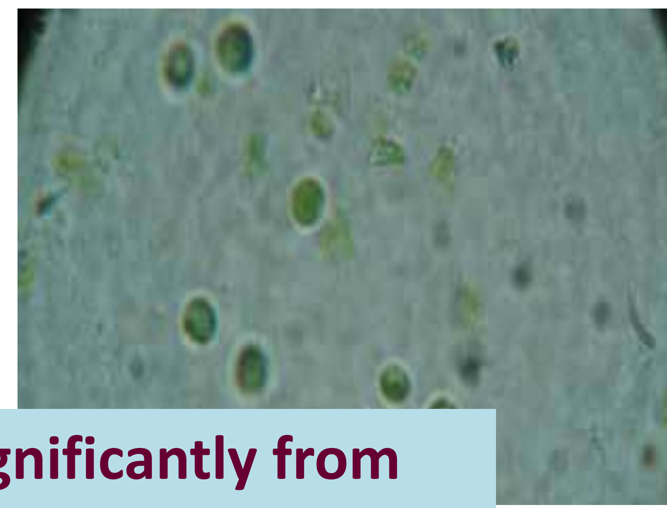
Inoculated *Chlorella* (2% w/v)

(0.9 x 10^5 cells / mL)

After 25 days

Growth of *C. minuttisima* in BGS with diff Conc. of Org Amend.

Parameter	Control (Media)	BGS + Organic amendment	BGS
Chlorophyll a	1.21	1.60	-
Chlorophyll b	1.93	2.06	-
Total Chlorophyll	2.91	3.66	-
Cell count (10^5 cells/mL			



inuttisima
(40x)

N (%) = 1.35
P (%) = 1.11
K (%) = 1.12

✓Increased significantly from initial value
(N= 0.88%; P= 0.58%; K= 0.87%)

(C) *Anabaena*

BGS (1 L)+ Organic amendments

↓

***Anabaena* 2%** (0.5 x 10^5 cells / mL)

↓ **After 25 days**

Growth of *Anabaena* in BG S with diff conc. of amendment

Parameter	Control (Media)	BGS + Organic amendment	BGS
Chlorophyll a	0.41	0.55	-
Chlorophyll b	1.31	1.46	-
Total Chlorophyll			
Cell count (10^5cells/mL)			

...w of ... GS (best media, 40x)

N (%) = 1.97
P (%) = 1.15
K (%) = 1.22

✓Increased significantly from initial value (N= 0.88%; P= 0.58%; K= 0.87%)

(D) *Nostoc*

BGS (1 L)+ Organic amendments

↓

Nostoc **(0.5 x 10^5 cells / mL)**

↓ **After 25 days**

Growth of *Nostoc* in BG S with diff conc. of amendment

Parameter	Control (Media)	BGS + Organic amendment	BGS
Chlorophyll *a	0.38	0.43	-
Chlorophyll b	[illegible]	[illegible]	-
Total Chlorophyll	[illegible]	[illegible]	[illegible]
Cell count (10^5cells/mL)	[illegible]	[illegible]	[illegible]

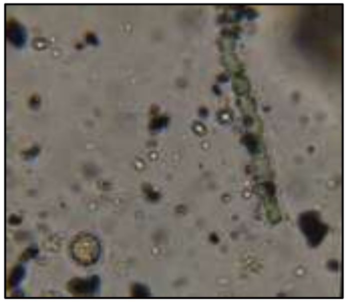
N (%) = 1.90
P (%) = 1.12
K (%) = 1.20

✓Increased significantly from initial value
(N= 0.88%; P= 0.58%; K= 0.87%)

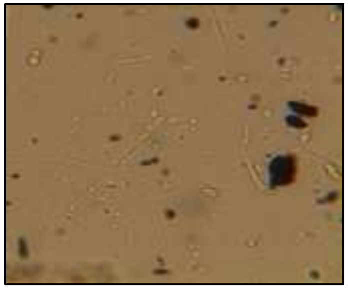
(*Micro gm/ml of medium)

BGA cultivated in BGS

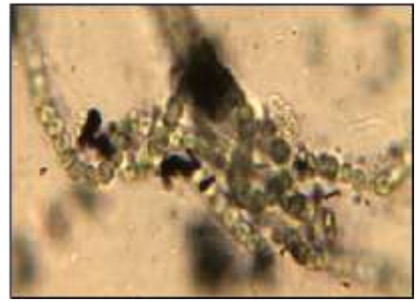
(All under 40X Phase Contrast Microscope)



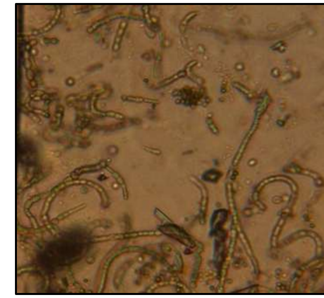
Anabaena (0 day)



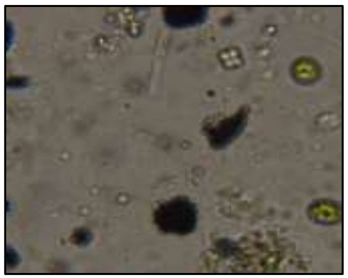
Anabaena (5th day)
Budding cells



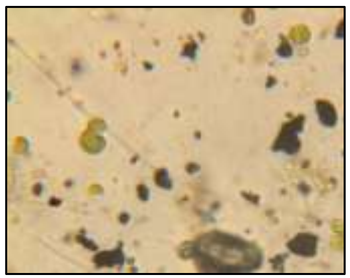
Anabaena (10th day)



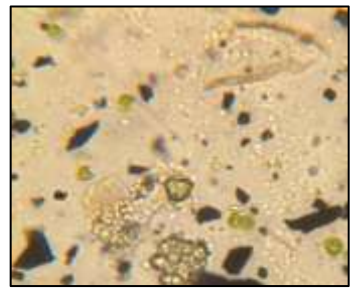
Anabaena (20th day)
At 10X



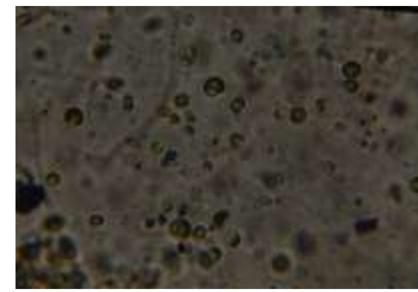
Chlorella (0 day)



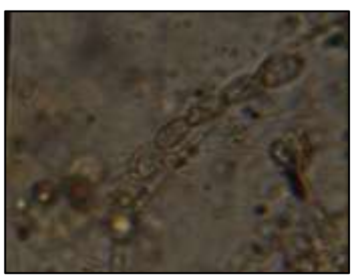
Chlorella (5th day)
Cell division



Chlorella (10th day)

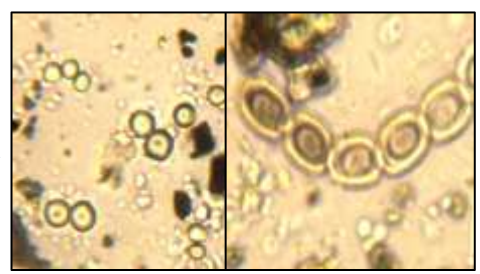


Chlorella (20th day)

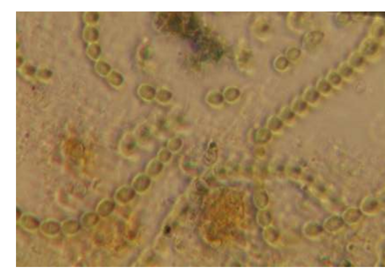


Nostoc

Nostoc (5th day)
Cell division



Nostoc (10th day)
Developing filaments



Nostoc (20th day)

BGS as CO-Composting Material

Composting with Biogas Slurry in Micromodel, IITD

Materials used in Composting

Wheat straw/ Paddy straw /Mustard waste/ Sugarcane waste

Neem cake

Jaggery

Compost

Biogas Slurry

E. foetida

Paecilomycerol, DPA, oxalic acid producer

P. variotii

Use of Biogas Slurry in Composting using Wheat Straw

- **Substrate Combination**

BGS :Substrate

4:1 (Wheat straw)

2:1 (Paddy straw)

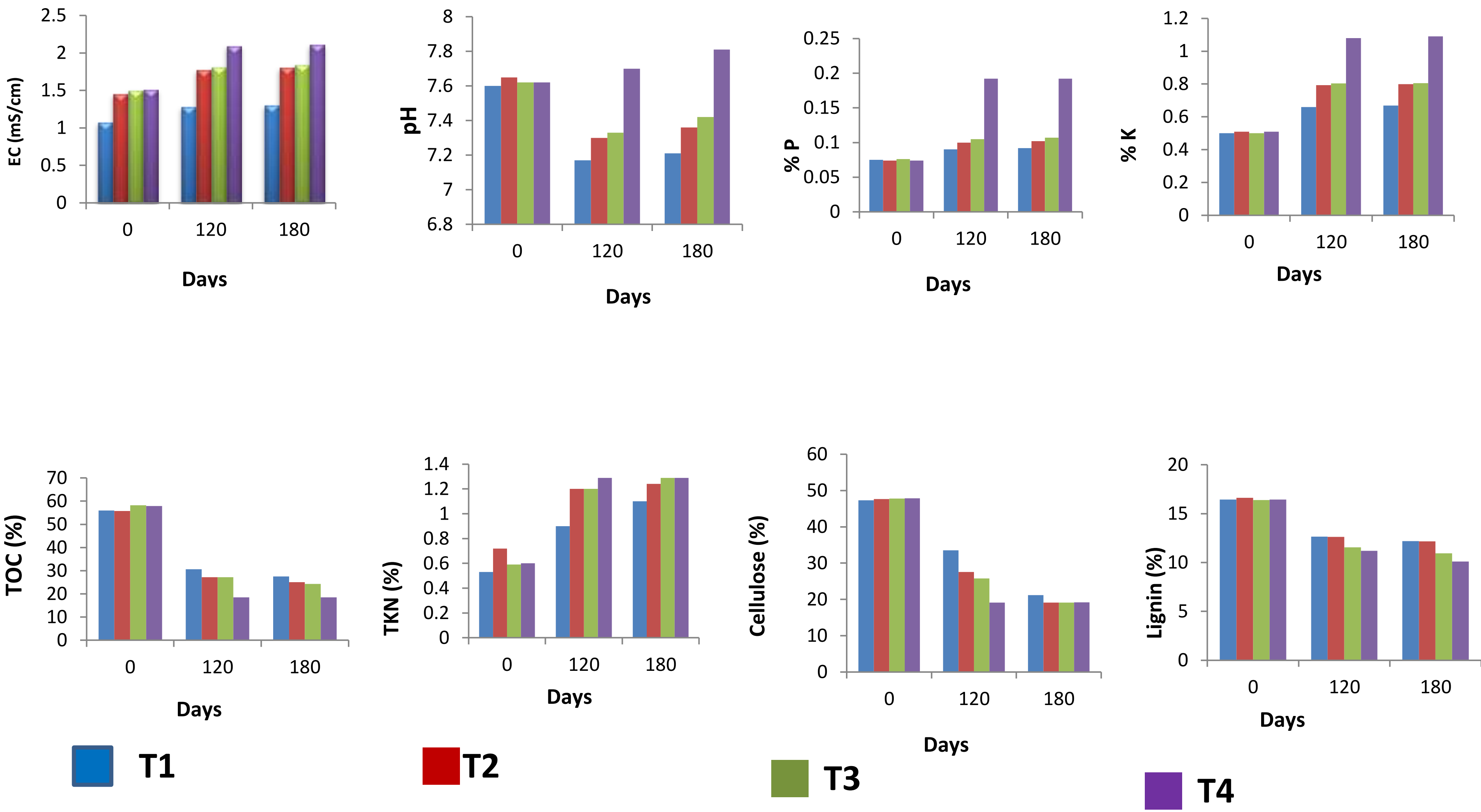
2:1(Mustard waste)

3:1 (Sugarcane baggase)

for ~ 65% moisture

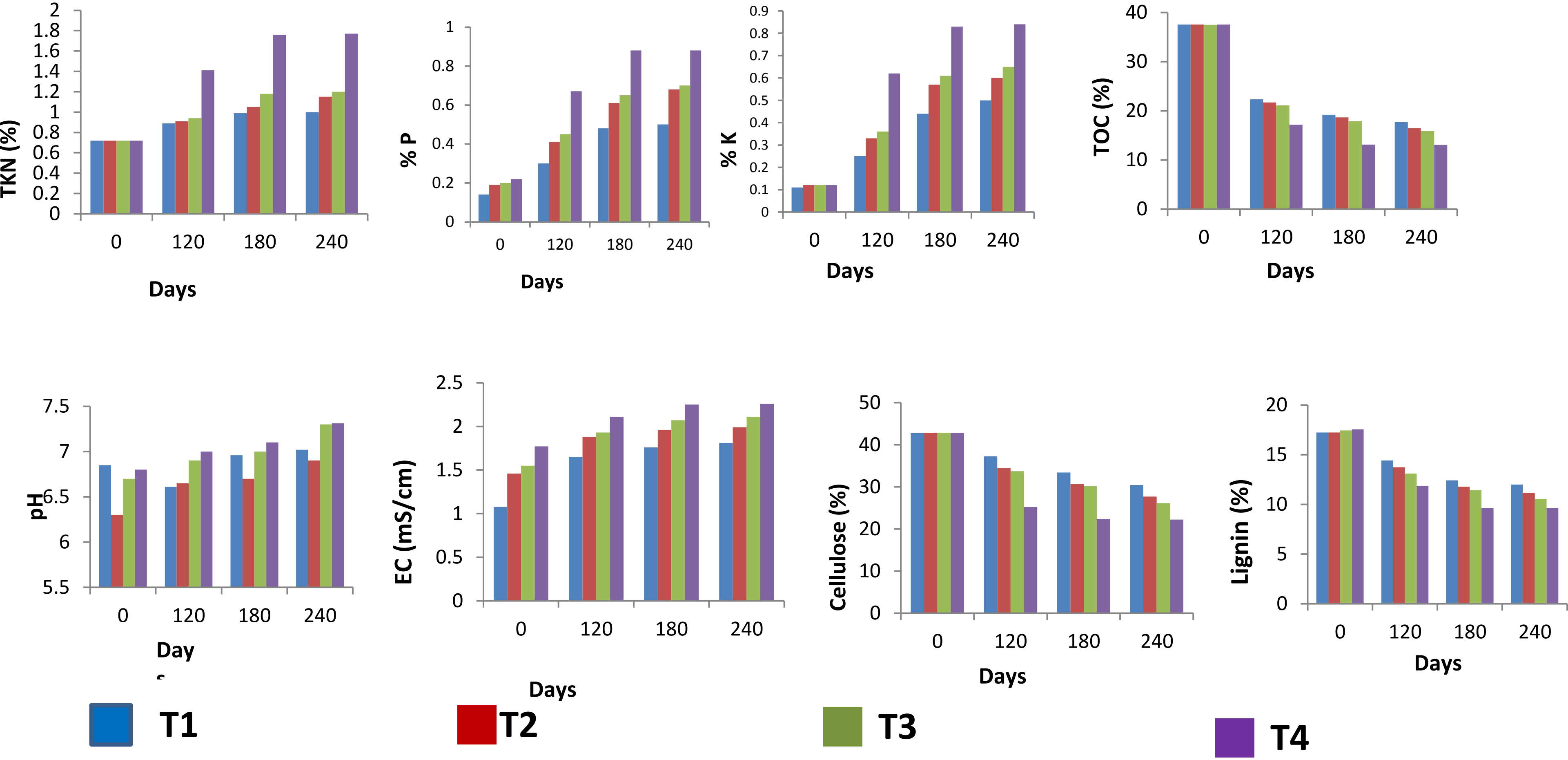
Treatments	Substrate combination for composting
T1	Straw + Slurry
T2	Straw + Slurry + Culture
T3	Straw + Slurry + Culture + Jaggery(0.5%) + Neem cake (0.1%)
T4	Straw + Slurry + Culture + Jaggery + Neem cake + Earthworm

Changes in parameters during composting of Waste (wheat straw) with BGS



✓**Saturation in four months in T4 and more than six months in T1**

Changes in parameters during composting of Waste (Paddy straw) with BGS



- ✓Stabilization in T4 within six months, in T1 in more than 8 months
- ✓Similarly, Mustard waste: T4 = 5.5 months, T1= 7 months
- ✓Sugarcane baggase: T4= 6 month, T1 >8 months

Use of BGS in Mushroom Cultivation

- Types of Mushrooms Cultivated:

1. ***Pleurotus sajor-caju*** (Dhingri)

2. ***Agaricus bisporus*** (Button)

(200kg wheat straw+800 Lts BGS)

2011-12

Compost Production

Spawn Run

Casing

Button Mushroom Cultivation Using BGS in Micromodel,IITD

Ready for Distribution

Mushroom Harvest

Fructification

2012-13

Compost Production
(400 kg wheat straw+1600 Lts BGS)

Spawn Run

Casing

Fructification

Button Mushroom Cultivation Using BGS in Micromodel,IITD

Mushroom Harvest

Ready for Distribution

Mushroom Cultivation at Shri Krishna Gaushala, Ghaziabad

Shri Krishna Gaushala, Ghaziabad

Compost Production

Spawn Run

Starting of fructification
(Shri Awasthi Ji, Gaushala)

Mushroom production using BGS at Micromodel IITD

Button Mushroom

Dhingri Mushroom

Yield of *A. bisporus* (Button) mushroom on BGS

Experiments Conducted during November – Feb.,2012 &2013

(Compost production=30days, Spawning +growth of mushroom fungi=30days)

- Quantity of waste (wheat straw) used: 200 Kg &300kg
- Quantity of compost formed: 125 kg &187.5kg.
- **Yield of mushroom: 24.09 kg/ 100 kg of compost in 2012**
- Yield of *Agaricus* mushroom : **20-22 Kg/100 kg of traditional compost**

Dhingri Mushroom Yield from Different Treatments of BGS

BGS - straw combination	**Mushroom yield (gm/kg dry substrate)**	**Biological efficiency (%)**
100% straw	729	72.9
90%straw+10% slurry	**950**	**95**
80%straw+20% slurry	700	70
70%straw+30% slurry	600	60
60%straw+40% slurry	530	53
50%straw+50% slurry	230	23
25%straw+75% slurry	NIL	-

Yield of *Pleurotus florida* (Dhingri) on BGS with Karanja cake

S.No	Treatment	Yield (g/Kg)
1	Control	740.4
2	90% WS + 10% (Cake + BGS)	975
3	80% WS +20% (Cake + BGS)	760
4	70% WS +30% (Cake + BGS)	357
5	60% WS +40% (Cake + BGS)	Nil
6	50% WS +50% (Cake + BGS)	Nil

Yield of *Pleurotus florida* (Dhingri) on BGS (from cattle dung mixed with mahua cake)

S. No	Treatment	Yield (g/Kg)
1	Control	700.36
2	90% WS +10% (Cake + BGS)	850.35
3	80% WS + 20% (Cake + BGS)	957.25
4	70% WS +30% (Cake + BGS)	686
5	60% WS +40% (Cake + BGS)	555.2
6	500% WS + 50% (Cake + BGS)	459.8

Cake and BGS = 60:40

Yield and Nutritional analysis of Mushroom fruit bodies cultivated on mahua cake based BGS

BGS mixed with straw combination	Proteins (%)	Total soluble sugars (%)	Fat (%)	Energy Kcal	P (mg/g)	K (mg/g)	Fe (ppm)
T1 (100% Straw)	29.6	32.33	2.01	1127.48	11.23	23.26	105.7
T2 (10%)	32.6	30.93	1.86	1149.2	11.56	23.46	129.6
T2 (20%)	33.42	31.06	1.826	1160.1	11.76	23.63	132.8
T2 (30%)	30.5	31.43	1.87	1122.3	11.35	23.06	134
T3 (10%)	36.23	29.06	1.84	1185	13.46	28.7	197.3
T3 (20%)	38.76	29.26	1.813	1220.26	15.0	29.86	200.6
T3 (30%)	34.61	29.46	1.826	1153.6	11.96	25.9	206.6

T_1 = 100% WS **T_2 = CD slurry control** **T_3= BGS plus DMC in 60:40**

Conclusions

Filtration

- Filtration distributed nutrients in both liquid as well as solid parts.

- 100% removal of solid (Colloidal) particles not possible by sand, sieve, straw ,Screw press filtration.

- Among all methods tried , **gunny bag method** was found suitable (>50% water removal) and can be employed at small biogas plants. However further work is needed.
- **Development of filtration unit using diff. mesh size sieves and motor (under progress)**

Centrifugation

- Centrifugation yielded **65% of water** with turbidity **1700 NTU.**
- **Moringa** and **alum** reduced turbidity from 1700 NTU to 99 and 97 NTU respectively.
- **Moringa** proved better than Alum..
- Sludge with 60% moisture vermicomposted with earthworms for 20 days yielded quality product rich in NPK.
- **Cost ??** involved in centrifugation (Total volume 500 L; Cake volume 20kg.; 3000 rpm) may be the limiting factor (~ 2.0 Lakhs).

Use of Coagulants:

- Among all coagulants tested, **alum (2%)** along with Dimethylamine **(DMA 0.016%)** produced best results (44% water removal with EC 13.9 mS/cm and pH 4.97 in <4 hr)
- The increase in pH **(7-7.5)** was possible with the use of **KOH and lime** but EC could not be decreased.
- **Moringa** seed powder removed 30% water, although it takes time (>12 hr) , may be useful as it enhances the manurial value of sludge.

Value Addition of BGS through BGA Cultivation:

- ***Chlorella, Anabaena and Nostoc :*** The use of amendments in BGS improved the growth of BGA.
  The liquid BGS with growth of *Chlorella* , *Anabaena* and *Nostoc* can be used as **liquid BGS based biofertilizers.**

- ***Azolla*** along with BGS after 20 days growth produced the product with enhanced nutritional content (NPK).- **Quality Solid Biofertilizer.**

- ***Use of NEOC and Leafy litter:*** Not only reduced water content ,also improved quality

Mushroom cultivation:

Pleurotus :

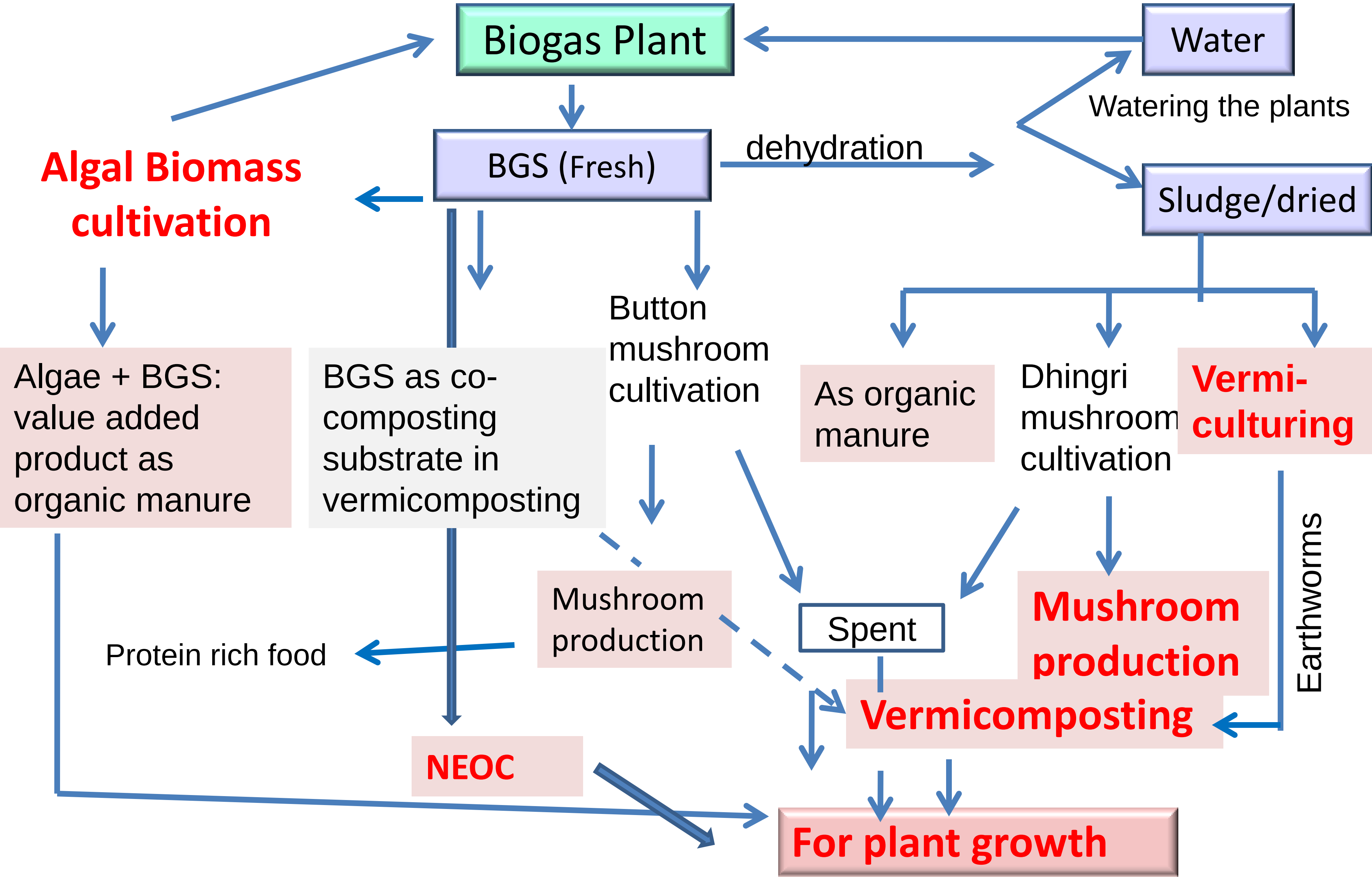
- **10% of BGS** (amendment) with paddy straw produced best results with 95% biological efficiency and high protein content. However, drying of slurry in this case is a problem.
- With the use of detoxified **Mahua cake (20%),** BGS further increased the quantity and nutritional quality of the mushrooms produced.

Agaricus:

- The compost using BGS produced better quantity and quality **(24 Kg** / 100 Kg of substrate as compared to 22Kg / 100 Kg of substrate) of mushrooms.

BGS As co-composting substrate:

- The use of BGS along with the microbial cultures and earthworms reduced the composting time by 35-45% (as compared to the use of BGS alone) and produced enriched compost



An Integrated Approach for BGS Handling and management

Future work:

1. Development of **Liquid** and Solid **Biofertilizers** i.e. *Rhizobium*, *Azotobacter*, *Azospirilum*, Ectomycorrhiza, etc.

2. Development of **Liquid** and Solid **Biopesticides** (*Trichoderma*, *Pseudomonas*, *Bacillus*, *Paecilomyces*,) using BGS.

3. Development of field level **Centrifuge** (giving best results with optimized Parameters) on decreased cost for BGS dehydration purpose.

4. More work on Use of Moringa as Coagulant.

5. Validation of reports on other uses of BGS.

THANKS

Industries / NGOs involved in BGS dehydration by centrifugation

- SKG Sangha : Non profit voluntary organization (150 L)
- KBK Chem Engineering Limited, **Pune** Maharastra (500 L)
- Torftech Group, Mumbai, **Maharastra** (500 L)

Research Organization

- **Tamil Nadu** Agricultural University (400 L)
- **Anna University,** Chennai (200L)
- Himachal Pradesh Agricultural University, **Palampur** (200 L)