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Special Issue on BIOGAS

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EDITORIAL

There is ample evidence to demonstrate that poor quality of life also reflects very low consumption of energy. Though basically it arises out of low or no purchasing power due to absence of economic surplus of any kind. Yet if we examine the rural scene we find that on one hand there is acute shortage of utiliseable energy and on the other hand large quantities of organic wastes, from cattle dung to numerous vegetational materials/wastes, capable of providing methane or fuel gas through bacterial fermentation are lying untapped. The reasons of course are mixed, depending upon type of material and circumstances. The reasons could be technological, social, political or administrative. We have taken as the focal theme for this issue, Biogas Energy. This is one class of substrate i.e. animal dung, is quite a proven one. No doubt there is scope for finding appropriate solutions for outstanding problems like cost-reduction, water-use reduction, slurry utilisation etc. It is also redeeming to note that very encouraging and successful work has been done on cost reduction of biogas plants.

Number of biogas plants in the country are reported to be of the order of half a million (and our neighbour China is reportedly having around 8 millions of them). The utiliseable potential is estimated to be at least 20 million. This is in view of the fact that at least 15% of the cattle owners are eligible (from the view point of number of cattle) to possess a biogas plant. If we take into the account utilisation of human excreta, through community toilets, for gas generation, and other fermentable materials like organic industrial wastes, non-edible oil cakes etc. (which do not need a major change in the technology) the potential is enormous.

But alas the pace of utlisation of this potential puts to shame the proverbial 'snails pace' more so if one analyses, in totality, the resource allocation and policy support for Biogas plants as compared to energy eating chemical fertiliser plants Plethora of scientific study and documentation, even from accepted 'high-temples' of knowledge, is available to establish far greater cost-benifit superiority of biogas plants over chemical fertiliser plants (not to speak of tremendous polluting capacity of the latter). Yet the unbriddled proliferation of the chemical fertiliser plants goes on. There is much more first hand hard evidence to further corrborate this issue, but space restricts their elucidation. This special issue on Biogas attempts to draw the attention of scientific community, decision-makers, planners and administrators to realise the strength of the nature's bounty-the organic wastes-to solve man-made energy crisis through fuel gas and organic fertiliser production. We have all the wherewithals but what we need is public awareness and political will.

Effect of Addition of Gypsum and Sulphur on Microbiological Activity and Biogas Production

*Dr. P. Rajasekaran and T. Srinivasan**

To evaluate the interactions of sulfidogenic and methanogenic microbial communities due to incorporation at various levels of gypsum (experiment. I) and elemental sulfur (experiment. II) along with cowdung, batch experiments were carried out at 28° ± 2°C for a period of eight weeks. Reduced microbial activity such as acid forming ($\times 10^{7}$), Cellulolytic ($\times 10^{4}$), methanogenic ($\times 10^{5}$) and sulfidogens ($\times 10^{3}$) leading to reduced gas output was observed as compared to control treatments in both the experiments. Addition of gypsum and elemental sulfur inhibited methanogenesis due to competitive interaction of sulfidogens for substrates in anaerobic environments, rich in sulphur containing compounds.

Interactions of various physiological groups of organisms seems to be affected due to incorporation of inorganic sulfur compounds. Reports by earlier workers (Wiafrey and Zeikus 1977, Khan and Trottier, 1978), indicated inhibition of methanogenesis and cellulolysis. They also compete with other types of bacteria for the available substrates in their common anaerobic habitats. Hence an attempt was made to study the influence of biogas production potential of cowdung due to the addition of gypsum and elemental sulfur besides the microbiological activity.

MATERIAL AND METHODS

Collections of Waste Materials :

The different waste materials employed in the study were obtained locally from the area located around Tamil Nadu Agricultural University Campus, Coimbatore.

Details of experiment carried out :

The raw cowdung and the inorganic sources of sulphur were mixed in different proportions using water as diluent and biodigested slurry as inoculum. The proportion varied depending upon the nature of sulphur sources. The slurry thus prepared was loaded in 2.75 litre capacity amber coloured bottles in triplicate, sealed air tight and allowed to undergo batch fermentation, the details of which are listed below ;

Effect of Gypsum on biogas generation : (Experiment—I)

Commercial grade gypsum was used as the inorganic sulfate source. Varying quantities of gypsum was mixed with fixed quantity of cowdung to give a final concentration of 4%, 3%, 2% and 1% sulfate content in the study. The details of the experiments are as follows ;

T_1 — Cowdung (425g); gypsum (425g); water (850g); biodigested slurry (50g) — 4% sulfate concentration.

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T_2 — Cowdung (425g); gypsum (283g); water (708g); biodigested slurry (50g) — 3% sulfate concentration.

T_3 — Cowdung (425g); gypsum (141g); water (566g); biodigested slurry (50g) — 2% sulfate concentration.

T_4 — Cowdung (425g); gypsum (70g); water (495g); biodigested slurry (50g) — 1% sulfate concentration.

T_5 — Cowdung (425g); water (425g); biodigested slurry (50g) as control.

The treatments were prepared in triplicated and allowed to undergo batch digestion at room temperature (28 ± 2°C) for a period of eight weeks.

The specimens were analysed for their total solids, volatile solids, and microbiological properties as per standard procedures discussed elsewhere (Lingaiah and Rajasekaran, 1986). The gas output was measured by water displacement method. The cellulose (Updegraff, 1969) hemicellulose (Goering and Van Soest, 1975) and sulphate (Massoumi and Comfield 1963) contents were also estimated. The total organic Carbon and Nitrogen were also determined as per standard procedures. The carbon dioxide content of the gas was estimated besides the observation of hydrogen sulphide production. The results obtained are discussed below.

Results and Discussion :

The results of physico-chemical analysis of cowdung and that of gypsum are presented in Table 1. The gas output as determined in ml/g of total and volatile solids destroyed for gypsum as well as sulphur incorporated treatments are presented in Tables 2, 2a. The distribution of various micro-organisms at the initial as well as final stages of digestion are presented in Tables 3 and 3a.

Depending upon the nature of the substrate employed, as feed materials, the physico-chemical properties of gypsum and cowdung varied. Similar observations were also reported by Hills and Roberts (1981) in cowdung. In gypsum, the moisture, total solids and volatile solids per cent estimated were 7.96, 92.04 and 8.12 respectively.

Total solids and TS destruction :

In the initial stage, the maximum TS per cent (26.99) was estimated in (T_1 experiment I) where gypsum was incorporated at 4 per cent sulfate level. The TS destruction in the same treatment was also observed minimum (13.6 per cent) wherein a total gas output of 3975 ml. was observed. The initial and per cent destruction of TS were 11.36 per cent and 26 14 respectively (T_1 experiment-II) where sulfur at 4 per cent concentration was incorporated, and the gas output recorded was 3650 ml. In the case of cowdung control treatment (T_5) of both the experiments I and II, the percentage destruction of TS and the gas output recorded were 48.98 and 56 21 and 8850 ml. and 8875 ml respectively. The gas output per g of TS destroyed obtained were 1083.11 and 1228.9 ml. in T_1 of both the experiments I and II, while their respective control treatments T_5 (in both experiments I and II) recorded comparatively higher gas output per g of TS destroyed (1836.10 and 1767.93 ml.) respectively. Similar reports by Barnett *et al* (1978) that maximum per cent TS destruction leads to maximum gas output lend support to the above findings.

Moreover, the optimum total solids suited for maximum microbiological activity and gas generation was observed by Singh *et al* (1980) and (1982) to range from 8 to 12 per cent. In our present study except experiment I, in all the other experiments the initial TS content was approximately found to range from 8 to 12 per cent. But in experiment II, the percentage destruction of TS was comparatively low due to incorporation of sulfur, while the percentage destruction of TS was less in T_1 (experiment I), due to the combined effect of high total solids and sulfate contents in gypsum. Both sulfur and gypsum might have caused a reduction in microbial activity and thus the quantity of gas generated per g of TS destroyed was observed low.

Volatile solids and VS destruction :

Similar trend as mentioned above was also observed in case of volatile solids, and VS destruction. In the initial stage, maximum and minimum VS per cent recorded were 20.6 (T_1) and 6.68 (T_5) of experiments I and II respectively.

Incorporation of gypsum and sulfur reduced the microbial activity which lead to lesser VS destruction. Thus, treatment T_1 in both the experiment recorded 15.15 and 25 47 per cent destruction of VS and 1274.04 and 1689.81 ml of gas per g of VS destroyed respectively.

In case of gypsum and sulfur incorporated treatments the pH ranged from 5.4—6 8. Thus, the buffering capacity got reduced and the low pH might have inhibited maximum proliferation of methanogenic bacteria, and thus lesser gas output was recorded. Therefore, the presence of sulfate and sulfur in excess concentrations reduced the methanogenic activity. Similar reports by Winfrey and Zeikus (1977)[1] and Khan and Trottier (1978)[2] lend support to the above findings.

Enumeration of microbial population in the slurry samples Acid forming bacteria :

Maximum acid forming bacterial populations ($\times 10^3$/g) were observed at the final stage in all the treatments of experiments I and II, which ranged from 50.27 (T_1) to 85.96 (T_5) and 48.06 (T_1) to 85.33 (T_5) respectively.

Acid forming bacteria cleave large chain lipid fractions and produce short chain volatile fatty acids. Acids thus produced form the intermediary products of fermentation during digestion, which form the substrates for not only methanogens but also sulfidogens as electron donors to reduce sulfate to hydrogen sulfide (Sorensen *et al.*, 1981).

In gypsum and elemental sulfur enriched experiments depending on the concentration of sulfur source added, the acid forming bacterial population decreased as against control T_5 treatments. This might be due to the drop in pH from around neutral conditions. According to Taiganides (1980) accumulation of volatile fatty acids in excess (over 2000 mg/litre) caused a drop not only in methane production were also inhibited the acid producing organisms themselves, due to reduction in pH. Since addition of gypsum and sulfur caused a decrease in pH, this might have resulted in reduced acid forming bacterial activity and VFA production.

In gypsum and sulfur incorporated experiments (I and II respectively), higher the sulfate or sulfur concentration lesser was the cellulolytic activity. Thus in treament T_1 of both the experiments I and II, the lowest cellulolytic activity was observed (7.53 and 6.67 $\times 10^4$/g) at the final stage respectively. Khan and Trottier (1978) reported that at 9 mm concentration of all inorganic sulfur compounds inhibited both cellulose degradation and methane formation. This lend support to the above findings.

Methanogens and Sulfidogens :

In an anaerobic ecosystem rich in sulfur compounds, competition for substrate between methanogens and sulfidogens were observed (Winfrey and Zeikus, (1977).[1]

The methanogens ($\times 10^3$/g) estimated in the final stage ranged from 44.06 (T_1) to 95 26 (T_5); 40.56 (T_1) to 96.13 (T_5 in experiments I and II respectively), while the sulfidogens ($\times 10^3$/g) ranged from 8.3 (T_5) to 33.76 (T_1) and 7.9 (T_5) to 34.33 (T_1) respectively. The populations of both methanogens and sulfidogens exhibited an increasing trend in the final stages. However, the proliferation of methanogenic populations in sulphate/sulfur enriched treatments, were significantly less than their respective control treatments. Thus in T_1 of both the experiments recorded the lowest methanogenic population (44.16 and 40.56 $\times 10^3$/g) and also the lowest gas production (3925 and 3650 ml) respectively. A positive correlation was found to exist between the sulfidogenic population enumerated and the concentration of sulfur-rich compounds. Therefore, a gradual inhibition of methanogens was noticed although complete inhibition did not occur. Kristjansson et al (1982) reported that in sulphate rich environments the rate of hydrogen consumption of *Desulfovibrio vulgaris* (a sulfidogen) was five times that of *Methanobrevibacter arboriphilus* which lead to inhibition of methanogenesis by sulfidogenesis.

Besides this the addition of higher concentrations of sulfate and sulfur might have also caused a reduction in pH and thus reduced the methanogenic activity. Similar results were reported by Winfrey and Zeikus (1977)[1] and Khan and Trottier (1978).[2] Incorporation of gypsum and sulfur might have reduced the growth of methanogenic bacteria, resulting in accumulation of hydrogen. This would drive the fermentation away from acetate production and towards the production of more proportionate leading to low gas production. Thus a kind of substrate oriented competition causing lesser gas production might have existed under such ecosystem. From the trend of the data, it was evident that incorporation of inorganic sulfur compounds caused a reduction in methanogensis.

GAS GENERATION

In both the experiments I and II, T_1 treatments recorded the lowest amount of gas (3925 and 3650 ml) respectively. As mentioned earlier, incorporation of sulfur compounds inhibited the maximum generation of gas output although total inhibition was not noticed. The production of hydrogen sulfide was also observed indicating the activity of the sulfidogens. Regarding the carbon-dioxide content, a gradual declining trend from the initial to the final stages of the experiments was observed. During the first week, the per cent carbon dioxide content ranged from 45.5 to 54.0 and 48.5 to 54.4 while at the last week of digestion the same ranged from 34.5 to 48.5 and 30.5 to 42.5 respectively. Similar reports by Barnett et al (1978)[8] lend suppprt to the above findings.

CONCLUSION

Addition of gypsum and elemental sulfur inhibited methanogenesis and reduced the total gas output. The production of hydrogen sulfide was also evident. The study provides evidence that the interaction between sulfidogens and methanogens is competitive in anaerobic environments, rich in sulfate salts.

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The authors wish to place on record the guidance offered and facilities provided by Dr. G. Oblisami, Professor and Head, Department of Agricultural Microbiology and Prof. K. R. Swaminathan, Professor and Head, Department of Bioenergy, of Tamil Nadu Agricultural University, Coimbatore towards the conduct of the study.

Table 1—Physico-chemical properties of various raw organic wastes and gypsum (Expressed in percentage)

Sl. No.	Waste Materials	Moisture	Total solids	Volatile solids	% of VS to TS	Sulfur	Cellulose	Hemi cellulose	Total organic carbon	Nitrogen	C : N ratio
1.	Cowdung	81.58	18.42	14.67	79.64	0.08	32.14	25.3	36.84	1.49	24.72
2.	Gypsum	7.96	92.04	8.12	8.78	15.01 (as sulfate)	—	—	—	—	—

Table 2—Physico-chemical properties and gas output of gypsum incorporated with cowdung treatments

Treatments	Total solids % I	Total solids % F	% destruction	Gas output in ml/g of TS destroyed	Volatile solids % I	Volatile solids % F	% destruction	Gas output in ml/g of VS destroyed	Total gas output over 8 weeks (ml)
T_1 CD : GY (4%sulfate)	26.99	23.31	13.60	1083.11	20.60	17.48	15.15	1274.04	3975
T_2 CD : GY (3%sulfate)	23.89	19.83	16.99	1200.74	17 69	14.81	16.28	1629.71	4875
T_3 CD : GY (2%sulfate)	18.77	14.30	23.81	1263.98	14.21	10.73	24.49	1623.56	5650
T_4 CD : GY (1%sulfate)	14.04	9.18	34.62	1327.16	10.52	6.73	36.03	1701.85	6450
T_5 CD alone	9.84	5.02	48.98	1836.10	7.35	3.85	47.62	2528.57	8850
CD	0.644	0.670			0.958	0.697			
r		—0.9510				—0.272			

I = Initial (7th day) F = Final (56th day)

CD = Cowdung GY = Gypsum

Table 2a—Physico-chemical properties and gas output of sulfur enriched cowdung treatments

Treatments*	Moisture % I	Moisture % F	Total solids % I	Total solids % F	% destruction	Gas output in ml/g of TS destroyed	Volatile solids % I	Volatile solids % F	% destruction	Gas output in ml/g of VS destroyed	Total gas output over weeks (ml)
T_1 CD : S (4% sulfur)	88.64	91 61	11.36	8.39	26.14	1228.96	8.48	6.32	25.47	1689.81	3650
T_2 CD : S (3% sulfur)	89.45	93.18	10.55	6.82	35.36	1239.95	7.98	5.21	34.71	1669.68	4625
T_3 CD : S (2% sulfur)	89.85	93.81	10.51	6.19	39.01	1395.20	7.54	4.57	39.38	1860.27	5525
T_4 CD : S (1% sulfur)	90.57	95.04	9.43	4.96	47.40	1515.66	7.05	3.73	47.09	2040.66	6775
T_5 CD alone	91.07	96.09	8.93	3.91	56.21	1767.93	6.68	2.93	56.13	2366.67	8875
CD			0.292	0.299			0.226	0.210			
r				—0.975				—0.975			

*CD = Cowdung ; S = Sulfur

I= Initial (7th day) F = Final (56th day)

Table 3—Distribution of microorganisms in gypsum incorporated with cowdung treatment at different stages of digestion (Expressed per g on oven dry basis)

Treatments*	Acid forming bacteria × 10^3		Cellulolytic bacteria × 10^4		Methanogens × 13^3		Sulfidogens × 10^3	
	I	F	I	F	I	F	I	F
T_1 CD : GY (4% sulfate)	23.83	50.27	11.17	7.53	20.90	44.16	6.12	33.76
T_2 CD : GY (3% sulfate)	28.46	53.76	14.54	9.54	25.17	53.66	5.75	29.23
T_3 CD : GY (2% sulfate)	34.53	66.87	18.36	12.94	28.90	66.76	5.37	25.00
T_4 CD : GY (1% sulfate)	39.53	77.90	20.97	14.80	37.00	78.75	4.88	22.57
T_5 CD alone	43.57	85.96	25.12	16.63	44.20	95.26	4.10	8.3
CD	2.865	0.919	2.405	1.556	2.502	4.668	0.095	1.651
r		0.956		0.932		0.980		−0.966

I = Initial (7th day) ; F = Final (56th day)
*CD = Cowdung ; GY = Gypsum

Table 3a—Distribution of microorganisms in sulfur enriched cowdung treatments at different stages of digestion (Expressed per g on oven dry basis)

Treatments *	Acid forming bacteria × 10^3		Cellulolytic bacteria × 10^4		Methanogens × 10^3		Sulfidogens × 10^3	
	I	F	I	F	I	F	I	F
T_1 CD : S (4% sulfur)	23.43	48.06	10.00	6.67	18.64	40.56	6.34	34.43
T_2 CD : S (3% sulfur)	27.50	56.80	14.77	9.30	24.03	51.15	5.52	30.76
T_3 CD : S (2% sulfur)	31.26	64.64	17.66	11.97	28.17	66.03	4.99	25.83
T_4 CD : S (1% sulfur)	37.57	75.96	20.90	13.73	38.70	75.70	4.62	23.17
T_5 CD alone	44.80	85.33	25.60	17.34	22.17	96.13	3.83	7.9
CD	2.678	4.391	2.756	1.932	1.651	3.879	2.021	1.127
r				0.988		0.993		0.880

I = Initial (7th day) ; F = Final (56th day)
* CD = Cowdung ; S = Sulfur

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Biogas Plants & Their Establishment

*H. C. Srivastava**

The article gives an overview of the biogas technology, status of its utilisation and rudimentary design calculations relevant to users. It also gives an informative resume of outstanding advantages at micro and macro levels that accrue, through adoption of this technology, supported by an illustrative case study.

1.0 Introduction :

Indian economy is predominantly agrarian and in agricultural set up livestock are traditionally an important asset from several considerations. One aspect of livestock wealth is utilisation of the dung in biogas plants as a feed stock material. When the feedstock is exclusively dung the term gobar gas is used in the common parlance. However term biogas is applicable in general when any type of biomass or biological waste is used as a feed stock. Thus biogas is a more comprehensive term which is inclusive of gobar gas. KVIC has been the main agency so far for the promotion of the biogas technology in the country. Of late the Deptt. of Non-Conventional Energy Source, Govt. of India, through the network of renewable energy development agencies (nodal agencies) of various states, has undertaken steps for the accelerating the transfer of this technology to rural areas. As of today, it is estimated that, there are about half a million biogas plants in the country. It is also estimated that not less than 75% of the plants are in working order. Though exact data in this respect is not available but random surveys do indicate high percentage of successful plants.

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2.0 Contemporary designs :

Two principle designs of biogas plants, in vogue, are the floating gas holder or KVIC type and the fixed dome or the Janata type. Others are variants of these two basic design. Each of these design has its own advantages and disadvantages. The main constraint in propagation of Janata design is requirement of masons of requisite skills and in KVIC design is the requirement of fabrication facility for gas holders. The main factor inhibiting the large-scale adoption of biogas technology are, the capital cost, requirement of technical support in interior areas and difficulties in utilisation of digested slurry.

A recent break-through claimed in cost reduction is in a variant of Janata design known as Deen Bandhu biogas plant developed by a voluntary agency AFPRO. Field trials have given promising results in respect of the techno-economic viability of this design. Cost reduction is reported to the tune of about 40%.

The main feed stocks which can be used for biogas production are animal dung, poultry waste, garbage, human excreta agricultural wastes, aquatic weeds like water hyacinth etc. So far there is no viable biogas plant design available for household level/small scale operation using wastes other than animal dung, human excreta and poultry droppings. However, methane (fuel gas) generation from other fermentable materials like dairy waste, distillery waste etc. is also possible and is being done, but it is traditionally not covered under the title of biogas plant.

3.0 **Pre-requisities :**

(i) Any person owning 3 baffaloes or five cows (stable bound), having a supply of a minimum of 50 litre water per day, a small area of about 5 m × 5 m in the vicinity and a capital of about Rs. 4,500/- can own a biogas plant. The capacity of the plant means the total quantity of fuel gas available from it in 24 hours (averaged for 365 days). In case of cattle which are not stable bound i.e. left for grazing in open, actual quantity of dung should be properly assessed. In no case it should be less than 50 kg. per day (for a 2 cum plant), to meet the cooking fuel need of a family of average size.

(ii) In case of night soil or human excreta based biogas plant there should be a minimum of 70 adults using a community latrine (to which the plant is attached.) There should be restriction on use of ablution water (1 litre per head per use would be desirable). Any quantity of water more than this will mean progressive reduction in plant performance.

Nightsoil based biogas plant is exactly similar, in case of Janata design, to dung based plant, but in case of KVIC design an additional water jacket is constructed in which the gas holder floats.

(iii) A biogas plant should not be normally constructed within 20 meters of a well or a hand pump.

(iv) The point of use of gas-kitchen/light point/ power appliance (duel fuel engine) site-should not be normally too far away from the plant. A distance of about 10-20 metres is ideal.

(v) The site should not be close to shady trees and should be as close to the cattle shed as possible.

(vi) The site should not obstruct village roads or pathways or approach to the house.

(vii) If, in addition to the above, the site is close to the farmland or orchards or vegetable plots it will be ideal as it will facilitate application of digested slurry for manuring of plants/crops/trees without incurring problems of its transportation over long distance.

3.1 **Sizing of plants :**

The capacity determination of a plant is governed by two major factors, one the quantity of gas required for different end-uses and the other is the quantity of feed stock available.

In this context following data will be helpful for a rudimentary calculation :

(a) Gas required—for cooking : 340 litre per day per person.

—lighting : 130 litre per lamp of, 1000 candle power.

(a) Gas required—for generating power : 425 litres per horse power per hour (in dual fuel engines, 80% biogas and 20% diesel oil is used)

(b) Gas generated—from night soil : 28 litre per person (adult)

(c) Ratio of water to dung for preparing feed slurry : 1 : 1

4.0 **Advantages** : The advantages of adoption of biogas technology, at micro and macro levels, can be enumerated as follows :

4.1 **Advantages at micro level :**

(i) Freedom from smoke and soot in kitchens and their attendent problems like adverse effect on health of women; food and blackening of utensils, walls and ceiling of the kitchen, etc.

(ii) Food is cooked in less time due to higher calorific value of the gas (as compared to traditional fuels like fire wood, dung cakes etc.) and freedom from back-breaking work of fuel wood/ agro waste collection if any.

(iii) Better health condition and spare time for women for other useful economic and recreational activities.

(iv) Increase in agricultural production through use of nitrogen and humus rich digested slurry as well as saving of expenses on purchase of inorganic fertilisers.

(v) Improvement in soil characteristics iike water retention, aeration and bacterial growth.

(vi) Better sanitation in the house and its vicinity due to conscentious collection of scattered cattle dung.

(vii) Employment opportunities for rural youth through construction and maintenance of biogas plants.

4.2 **Advantage at macro level :**

(i) Reducing deforestation due to felling trees for fuelwood and reduction of attendant problem of soil erosion, floods, droughts, loss of agricultural production etc.

(ii) Reduced consumption of inorganic fertilisers leading to conservation of scarce foreign exchange and overall strengthening of national economy.

(iii) Reduction of ecological degradation like leaching of unused fertilisers into ground water or being carried away with the runoff into surface waters.

(iv) Providing electrical/mechanical power for rural industrialisation water pumping, community health facilities etc. through large/community biogas plants and saving on cost of traditional fuels. For example a 5 H. P. dual fuel engine running on 20% diesel and 80% biogas for 4 hours per day for 25 days a month will accrue a nett saving of 88 liters of diesel per month i. e. about Rs 350/- per month.

5 0 **Biogas Plants vs Chemical Fertiliser Plants-a case study :**

An interesting case study carried out by Prof. A K N. Reddy of Indian Institute of Science, Bangalore on comparative evaluation of biogas plants and chemical fertiliser plants, states that a coal-based feriliser plant costing Rs. 40 crores can be replaced by 26, 150 biogas plant costing Rs. 26 crores only. Besides nett saving of Rs. 14.0 crores (35%) in the capital investment it has following advantages :—

(a) Employment generation will be 130 times more.

(b) Prosperity will be diffused to 26,190 villages.

(c) Energy will be generated rather than being consumed.

(d) Total saving of cost on :

—Packing

—Transport

—Storage

—Controlling pollution (due to about 50% fertiliser leached to ground water or entering surface waters)

To evolve simple and cheap technique for Slurry Utilization

*S. N. Pathak**

Energy crisis and fast depleting natural resources has proved the importance of renewable sources of energy. In search for renewable resources biogas plants established their recognition. Besides fuel gas they provide humous and nitrogen rich manure. Present paper is a study to increase the manurial value of slurry by addition of different waste materials.

Introduction :

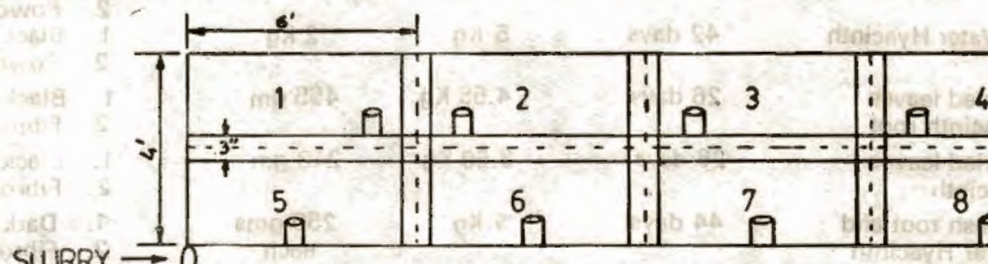
Slurry is an important product of Gobar Gas Plant. In China Gobar Gas plants have achieved more recognition as fertilizer plants than gas plants. Slurry is collected through outlet of gas plant. During fermentation in the gas plant about 27% of the added dung is converted into combustible gas and a residue of 73% becomes available to be used as manure. Acording to the experts of biogas field, without the spent slurry Gobar Gas plant is uneconomical.

Chemical Properties :

Slurry is chemically suitable for soil and acts as a natural fertilizer, after chemical analysis following results has been obtained ;—

pH	7.5
Total Solid	12.5%
Moisture	87.2%

By burning cow dung cakes we burn our manurial value i.e., Nitrogen, potassium, phosphorours & carbon. Slurry as a general is quite rich in both nitrogen and humous. Due to its humous content it acts as a SOIL CONDITIONER (of gobar).



Diagramatic Reprsentation of Slurry Utilization

Physical Properties :

Slurry is a homogeneous mixture of water and digested dung. It is dark brown or black in colour, semi solid and sticky in nature.

Further the manurial value of slurry can be increased without adding any cost, by composting slurry with different waste materials such as leaves of *Ipomea fitulosa*, water hyacinth, leaves & stem of Banana, rice

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straw, sugar cane leaves etc. composting of fresh or dried material by putting layer on layer. For large quantity a series of eight pits is useful. One to be filled for six months further allowed to decompose for another six months then emptied in action. One pit is being filled, second is under decomposition and third is empty.

Such method assures regular supply of compost, free of weedseeds, harmful insects etc.

Composting is a biochemical process in which organic materials are decomposed to humous like materials. Optimum moisture content for composting is 50-60%. If too much water is added, the compost becomes compact and anaerobic condition develops. If the moisture is too little the composts tends to dry out and the rate of decomposition slows.

Methodology :

Experiment was done on laboratory basis. Fresh as well as dried material was decomposed in twelve plastic troughs for different number of days. Materials were thoroughly mixed with slurry. After mixing and drying the Carbon, Nitrogen, Potassium and Phosphorous percentage is analysed.

Details of the experimental setup :

Setup No.	Substances used for compositing	Number of days for Decomposition	Quantity of slurry	Quantity of substances	Physical state
1.	Slurry + Fresh Behaya leaves	42 days	5 Kg	½ Kg	1. Dark Brown 2. Powder form
2.	Slurry + Water Hyacinth Roots	42 days	5 Kg	2 Kg	1. Black 2. Fibrous
3.	Slurry	35 days	5 Kg	Nil	1. Dark brown 2. Powder like
4.	Slurry + Water Hyacinth fresh leaves	42 days	5 Kg	2 Kg	1. Black 2. Powder like
5.	Slurry + dried leaves of Water Hyacinth root	26 days	4.55 Kg	455 gm	1. Black 2. Fibrous
6.	Slurry + dried leaves of Water Hyacinth	26 days	3.60 Kg	248 gm	1. Black 2. Fibrous
7.	Slurry + Fresh root and leaves of Water Hyacinth + Fresh leaves of Behaya + Fresh leaves of Banana	44 days	5 Kg	250 gms each	1. Dark Brown 2. Fibrous
8.	Slurry + Fresh leaves of Banana	44 days	6.5 Kg	250 gm	1. Dark Black 2. Fibrous
9.	Slurry + Rice straw	26 days	6.5 Kg	250 gm	1. Dark black 2. Fibrous
10.	Slurry + Rice straw	26 days	5 Kg	250 gm	1. Dark brown 2. More fibrous
11.	Slurry + Cane trace dried	26 days	5 Kg	200 gm	1. Dark brown 2. Powder
12.	Slurry + dried leaves of Behaya	26 days	4.55 Kg	450 gm	1. Black 2. Powder

After drying the samples of setup No 1 to 12 element analysis for Carbon, Nitrogen, Potassium was performed. Result obtained are as follows :

Setup No.	pH	Carbon %	Nitrogen %	Potassium %
1.	6.9	21.0	1.498	2.59
2.	6.6	21.6	1.4	2.15
3.	6.5	24.9	1.148	1.54
4.	6.6	22.05	1.316	1.61
5.	6.8	17.7	1.19	2.05
6.	6.6	21.3	1 246	1.70
7.	6.6	30.7	1.296	4.34
8.	7.5	31.9	1.20	1.52
9.	7.3	25.5	1.18	1.42
10.	7.2	14.7	1.16	1.82
11.	6.6	22.2	1.21	1.60
12.	6.9	22.1	1.20	1.50

When dung was analysed following results were obtained :

S. No.	Material	Carbon % (C)	Nitrogen % (N)	Potassium % (K)	Phosphorous % (P)
1.	DUNG	34 to 34.2%	0 91 to 0.93	0.78 to 0.90	0.62 to 0.70

Conclusion :

Above data shows that by mixing some waste substance which are useless for animal kingdom because they are not eaten by animals, increased the elemental value of dung.

It is now clear from the above data that mixing of fresh Behaya leaves, fresh Water Hyacinth in slurry is more advantageous.

Therefore it is suggested to get more fertilizer one should add his slurry with fresh behaya leaves as well as with water hyacinth.

Biogas Generation-Effect of Mixing Effluent Slurry with Fresh Cattle Dung

*S. K. Sharma, J. S. Saini, I. M. Mishra & M. P. Sharma**

More than 70% population of India are living in villages. Village people are utilising cow dung for production of biogas for meeting out their domestic energy requirements. The main product of an aerobic digestion of cattle dung are biogas and nutrient rich effluent slurry ie. biofertilizer. It has been observed that the effluent slurry is not completely digested due to some technical problems. In order to extract the residual energy from incomplete digested effluent slurry and to improve the economics of existing biogas plant it is very essential to recycle a part of effluent slurry mixed with fresh cattle dung. In view of this, laboratory study have been made by the author to study the effect of mixing incomplete digested effluent slurry with fresh cattle dung The result shows that as the percentage of effluent slurry in fresh dung slurry is increased the total gas production is also increased.

Introduction :

With increase in energy demand and decrease in supply of fossil fuels, the search for new sources of energy, specially renewable sources of energy, is intensifying. Microbial conversion of organic matter to the combustible methane gas is indigeneous to natural anaerobic ecosystems. Organic wastes can be converted into various end products as described by Hobson et. al 1974. The environmental consciousness to rural/tribal folk restrict forest denudation with ample supply of fuel to provide the recent impetus for into methane generation by anaerobic digestion of organic wastes/residues mainly cettle waste and agro/forest residues. The main product of anaerobic digestion is biogas and nutrient rich effluent i.e. biofertilizer. Biogas is a smokeless, inflamable gas which consists of atleast 55% methane and rest of carbon dioxide. Some traces of hydrogen sulphide, ammonia are also present (Probstein, 1982). However the composition of biogas depends largely upon the raw material used and the operating parameters employed during anaerobic digestion e.g. the cattle dung obtained from two cattles of same age group, cannot be similar in composition, even if they are fed with similar type of rations due to metabolic dissimilariation.

Rural people are using cattle dung for biogas generation for meeting their domestic energy requirements. It has been observed that in the existing biogas plants, the effluent slurry is not fully digested due to some technical problems. In order to extract the residual energy from partially digested effluent slurry and to improve the economics of existing biogas plants it is considered worth-while to recycle a part of effluent slurry, mixed with fresh cattle dung. With

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this view laboratory studies have been conducted to study the effect of mixing effluent slurry with fresh cattle dung and the results are reported in this paper.

Materials and Methods :

Fresh cattle dung was collected from the Roorkee University campus dairy. Seven Erlenmeyer flask of four litre capacity each were used as batch digesters, which were fed with cattle dung, tap water and effluent slurry. In first six digesters, designated as S_1, S_2, S_3, S_4, S_5, and S_6, cattle dung and water was mixed in 1 : 1 ratio (W/V) to make slurry. Now these digesters were fed with different quantity of effluent, starting from zero to fifty per cent of the dung water slurry. The effluent slurry was obtained from a Janta type biogas plant which was operating on cattle dung, in the Centre. For reference purpose, one litre of effluent slurry only, was also kept for anaerobic digestion in the seventh digester, designated as S_7. The ratio details of all the samples is given in Table-1.

Table 1—Detail of Samples

Sample No.	Quantity of wet cattle dung gms	Quaatity of water mls	Quantity of effluent slurry mls
S_1	1000	1000	00
S_2	1000	1000	200
S_3	1000	1000	400
S_4	1000	1000	600
S_5	1000	1000	800
S_6	1000	1000	1000
S_7	00	00	1000

All of the digesters were kept in water bath at a constant temperature of 36°±0 5°C and the stirring of digester content was made at least twice in a day for five minutes by means of magnetic stirrers. Each digester was provided with gas exit part attached to water displacement gas measuring system. The generated gas was measured and recorded daily and the digestion was continued for a total period of eight weeks The following is the list of test methods used for the analysis of samples.

(i) *Moisture contents* : By keeping a known weight of the sample in an oven at 75°C for 24 hours and the loss in weight was determined.

(ii) *Volatile Matter* & *Ash* : By ignition at 575°C in muffle furnace for five hours, (Standard Methods 1975).

(iii) *pH* : By using Control Dynamics pH meter model No. AP × 175E with gel filled ingold electrode.

(iv) *Cellulose* & *Lignin* : By potassium permanganate method (Vansoest & wine, 1968).

(v) *Carbon* : By using standard formula (Tumlos, 1981).

(vi) *Methane and Carbon-dioxide* : By using Orsat gas analyser.

(vii) *Total Volatile Fatty Acids* : By direct titration method (Dilallo & Albertson, 1961).

(viii) *Total Nitrogen* : By Kjeldahl's digestion method. (Bassett. J. et. al, 1978).

(ix) *Protein* : Kjeldahl's digestion method (Woodman, 1941).

Result & Discussion :

Analysis of fresh cattle dung & effluent is given in Table-2. There is 79-36% of volatile matter out of total solid matter, in cattle dung. Total volatile fatty acids are 1496 PPM and pH is almost neutral 7.06. The carbon to nitrogen ratio is 38, and this should be a limiting factor in anaerobic digestion. Low lignin to cellulose ratio (0.75) suggests the degree of digestibility of organics. In anaerobic digestion process, cellulolytic bacteria constitute a small fraction of the total acidogenic population (Scharer & Moo-Young, 1979). Probably due to this small fraction of cellulolytic bacteria some cellulose is also digested, during anaerobic digestion. Weekly gas

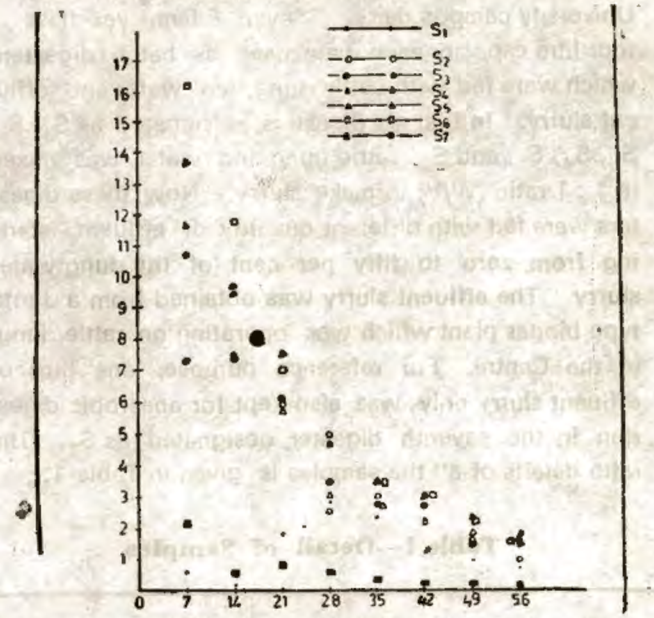
Table 2—Analysis of Fresh Cattle Dung and Effluent

Test	Cattle Dung	Effluent
1. Moisture content %	87.70	91.54
2. Solid concentration %	12.30	8.46
3. Volatile Matter %	79.36	76.48
4. Ash %	20.64	23.52
5. Carbon %	44.08	42.48
6. Nitrogen %	1.16	1.24
7. Protien %	7.40	7.91
8. Cellulose %	28.65	19.84
9. Lignin%	21.46	13.68
10. Carbon/Nitrogen ratio	38.00	34.26
11. Lignin/Cellulose ratio	0.75	0.69
12. Total volatile fatty acids PPM (as acetic acid)	14.98	9.932
13. pH	7.06	7.05

production rates from seven batch digesters are shown in Figure-1 and Table-3, which shows that in the first week, sample S_6 yielded 25.77 times gas as compared to S_1. The gas production rate in all of the seven digesters is in following decreasing order.

$$S_6>S_5>S_4>S_3>S_2>S_7>S_1$$

In case of sample S_1 which was not seeded, with effluent slurry, the gas production rate was some what higher in the first week with a decrease in second week, and continuous increase upto fourth week. Thereafter the production rate went on decreasing upto eighth week. It shows that if the cattle dung is not seeded with effluent slurry, then the normal gas production starts in third week, although methanogenic bacteria are present in cattle dung but the usual gas production starts latter probably (i) due to less concentration of methanogenic & non-methanogenic bacteria and (ii) due to conversion of the insoluble organic matter, i.e. fats, proteins & cellulose etc. of cattle dung, is converted into soluble organic matter by their decomposing organisms, which is then converted into organic acids by acid forming or non-methanogencic bacteria. These acids are then used or substrate by the methanogenic bacteria to form methane and carbon dioxide (Tumlos 1981).



DIGESTION PERIOD (NO. OF DAYS)

↑WEEKLY GAS PRODUCTION (LITERS/KG OF WET CATTLE DUNG)

Fig. 1 Weekly gas production versus digestion period

This conversion process of organic matter into biogas takes some time for stabilization which is about 20 days as seen by our experiment. Similar phenomena happens in the case of freshly started biogas plant. If the cattle dung is not seeded with effluent, then the usual gas production starts in third week but in order to take the gas immediately i.e. after 1-3 days, the cattle dung should be seeded with at least 20-30% of effluent obtained from another biogas plant.

It is clear from Table-3, that in samples from S_2 to S_7, the gas production was higher in first week and then went on decreasing upto eighth week. The maximum quantity of gas (50.39 litres) was produced from Sample S_6, which was having highest percentage

Table 3—Weekly gas Production in Litres/kg of wet Cattle Dung

Sample No.	Ist	2nd	3rd	4th	5th	6th	7th	8th
S_1	0.63	0.14	1.84	2.79	2.32	1.23	0.99	0.76
S_2	7.32	7.51	5.58	2.49	3.00	1.30	1.59	0.90
S_3	10.75	7.47	6.12	3.50	2.76	2.76	1.56	1.63
S_4	11.75	9.49	5.86	3.09	2.73	2.26	1.85	1.79
S_5	13.78	9.72	7.52	4.70	3.52	3.09	2.31	1.53
S_6	16.24	11.72	6.96	4.92	3.56	3.10	2.24	1.65
S_7*	2.19	00.56	0.75	0.57	0 38	0.26	0.22	0.14

*Sample S^7 : Shows weekly gas production in litres/litre of effluent slurry.

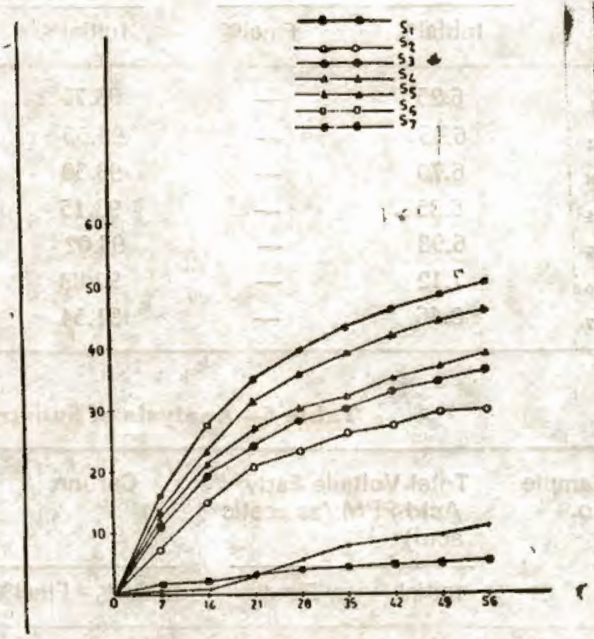
of effluent slurry as compared to other samples. This is amply demonstrated in Figure 2, and Table 4.

Sample S_2 having minimum effiuent slurry (≃10%) out of all samples, gave 30.07 litres of gas. It is thus clear that by increasing the quantity of seed (effluent slurry), in cattle dung, the total gas production capacity increases. This may be explained by the fact that by increasing the quantity of effluent, the number of micro-organism increases and thus there is fast degradation of organic matter with resultant increase in gas formation. The total gas formation for all the seven digesters, in eight weeks digestion period, is in the following order :

$$S_6 > S_5 > S_4 > S_3 > S_2 > S_1 > S_7$$

Table 5 and 6, present the results of analysis of substrate before and after anaerobic digestion. The solid concentration of all the digesters matter was between 6.25% to 8.46% where as only in case of seeded samples from S_2 and S_6, the solid concentration was almost similar and between 6.45% to 7.12%.

The destruction of volatile matter in digesters S_1 to S_4, increased in the same order. The measurement of pH of all the digesters slurry was found to be neutral, which is the optimum range for successful anaerobic digestion and more gas production. (Ferguson, et.al 1984). The total volatile fatty acids were in decreasing order from S_1 to S_7 and in the optimum range.



DIGESTION PERIOD (No. OF DAYS)
↑TOTAL GAS PRODUCTION (LITRES/KG OF WET CATTLE DUNG)

Fig. 2 Total gas production versus digestion period

Analysis of gas samples in third week of digestion period have shown that the percentage of carbondioxide in all the samples ranges from 37% to 39%.

Table 4—Total Gas produced in Different Samples (Liters/kg of Wet Cattle Dung)

Sample No.	1st	2nd	3rd	4th	5th	6th	7th	8th
S_1	0.62	0.77	2.61	5.40	7.72	8.95	9.94	10.71
S_2	7.32	14.81	20.79	23.28	26.28	27.58	29.17	30.07
S_3	10.75	18.17	24.29	27.79	30.55	33.31	34.87	35.50
S_4	11.75	21.24	27.10	30.19	32.92	35.18	37.03	38.82
S_5	13.78	23.50	31.02	35.72	39.24	42.33	44.64	46.17
S_6	16.24	27.96	34.92	39.84	43.40	46.50	48.74	50.39
S_7*	2.19	2.75	3.45	4.02	3.40	4.66	4.88	5.05

*Sample S_7 : Shows total gas production in litres/litre of effluent slurry.

Table 5—Analysis of Substrate Before & After Anaerobic Digestion

Sample No.	Solid Concentration		Moisture concentration		Volatile Matter		Ash	
	Initial%	Final%	Initial%	Final%	Initial%	Final%	Initial%	Final%
S_1	6.25	—	93.75	—	79.36	74.52	20.64	25.48
S_2	6.45	—	93.55	—	79.04	70.94	20.96	29.06
S_3	6.70	—	93.30	—	78.67	70.08	21.33	29.92
S_4	6.85	—	93.15	—	78.51	68.40	21.49	31.60
S_5	6.98	—	93.02	—	78.30	67.35	21.70	32.65
S_6	7.12	—	92.88	—	78.17	65.18	21.83	34.82
S_7	8.46	—	91.54	—	76.48	74.38	23.52	25.62

Table 6—Analysis of Substrate Before & After Anaerobic Digestion

Sample No.	Total Voltaile Fatty Acid PPM (as acetic acid)		Carbon		Total Nitrogen		Protein		pH	
	Initial	Final	Initial%	Final%	Initial%	Final%	Initial%	Final%	Initial	Final
S_1	1496	1185	44.08	41.40	1.16	1.20	7.40	7.65	7.04	6.92
S_2	1448	980	43.91	39.40	1.17	1.21	7.46	7.71	7.04	7.05
S_3	1400	755	43.70	38.93	1.18	1.23	7.52	7.84	7.04	6.99
S_4	1376	710	43.61	38.00	1.18	1.23	7.52	7.84	7.04	6.96
S_5	1342	565	43.50	37.41	1.19	1.22	7.59	7.78	7.05	7.02
S_6	1310	540	43.42	36.21	1.19	1.25	7.59	7.97	7.05	7.06
S_7	932	477	42.48	41.32	1.24	1.28	7.91	8.16	7.05	7.15

Rest of the gas was assumed to be consisting of methane.

Conclusion :

The results of experiment conducted on mixing of effluent with fresh cattle dung from zero to fifty per cent, have shown that as the percentage of effluent slurry in substrate is increased, the total gas production increases. Further, this mixing brought the early gas production and more digestion of cattle dung.

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National Productivity Council
New Delhi

Factors Influencing Biogas Generation, Operation and Maintenance of Digesters

*P. K. Singla**

The paper describes about the anaerobic digestion and various factors influencing the anaerobic digestion and generation of biogas. Maintenance of biogas plants and digester. Brief discription of biogas and its application in internal combustion engines. Conversion of small existing sparke Ignition engines to operate on biogas has also been discussed in this paper.

Introduction :

To maintain an anaerobic digestion system that will stabilise an organic waste efficiently, the non-methanogenic and methanogenic bacteria should be in a state of dynamic equilibrium. To establish and maintain such a state, the reactor contents should be devoid of dissolved oxygen and free from inhibitory concentration of such constituents as heavy metals and sulphides. Also the pH of the aqueous environment should range from 6.6 to 7.6. Sufficient alkalinity should be present to ensure that the pH will not drop below 6.2, because the methane bacteria cannot function below this point. When digestion is proceeding satisfactorily the alkalinity will normally range from 1000-5000 mg/ltr and the volatile-acids will be less than 250-500 mg/liter. A sufficient amount of nutrients, such as nitrogen and phosphorous, should also be available to ensure the proper growth of the biological community.

Temperature is another important environmental parameter. The optimum temperature ranges are the mesophilic, 30-38 C and the thermophilic 49.57°C. Biogas plants are designed either to process a given amount of waste material or to produce a given quantity of gas for a specific use. To justify the construction of a gas plant, three prerequisites must be met :

1. The smallest gas plant that can be justified economically should be able to produce enough cooking gas for a family of four when efficient burners are used, that is 12-15 ft^3 ($0.34-0.42m^3$) per person per day of gas with methane content of 60% or more.
2. There should be enough water available to make a slurry of raw material fed to the digester. In the case of cow dung, one part of water is required for every part of dung (by volume). In the case of night soil, flushwater per person per day should be about a litre, since excessive dilution is not conducive to methane fermentation (1).

Irrespective of the approach, an understanding of the parameters that govern the process of anaerobic digestion is essential in developing criteria for biogas plants.

Temperature :

Process temperatures directly affect processes conditions by controlling micro-bial growth rates. As the mesophilic process temperature is decreased below the

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optimum range of $33^{\circ}-38^{\circ}C$, the net microbial growth rate decreases and the minimum solids-retention time for process-stability increases. The same holds good for a shift in temperature in thermophilic range.

The methane bacteria are very sensitive to sudden temperature changes and for optimum process stability the temperature should be controlled very carefully. With a narrow range of the selected operating temperature, it should at least be protected from sudden temperature changes. The reaction rate is greater in the thermophilic range than in the mesophilic and as a result any upset in the operation (e. g. accumulation of volatile solids) will occur more rapidly, thus giving the operator less time to detect and correct the upset. However, for the same reason, the recovery rate is also much quicker. The effect of temperature on gas yield using cow-dung reed and a detention time of 7 days is shown in Table-1.

Experimental studies carried out in Japan showed that the amount of gas generated per unit weight of urban waste under mesophilic was 320-340 ml/gm/day at a loading of 3.8-3.9 gm/l/day while under thermophilic conditions the gas generated was 350-400 ml/gm/day at a loading rate of 9.0 gm/l/day.

Temperature control can be achieved by insulating the digester or heating internally or externally and insulating the digestor. To minimise the heating requirements, the insulation of digestor with materials such as leaves, saw dust and straw may be warranted. These materials may be composted in an annular ring sorrounding the digester and the heat generated during composting transferred to the digester contents.

Seeding of the Digestor

The formation of biogas is a micro-biological process. One group of organisms, the acid formers, is more abundant. Methane bacteria are less abundant. Waste materials containing no manure will not have naturally occupying methane producer in large numbers. Generally, actively digesting sludge from a municipal digester, material from a well rotted manure pit or cowdung slurry may be used as the seed to start up a new biogas plant.

The successful operation of a digester depends on establishing and maintaining a balance between the acid and methane-forming bacteria. If the digester accumulates volatile acids as a result of over-loading, the situation can be corrected by reseeding and temporarily suspending the feeding of the digester or by the addition of lime.

Mixing :

Methane formation is a biochemical process dependant upon intimate contact between the micro organisms and the waste material. Various mixing methods that may be considered are (a) gas recirculation (b) mixed liquor recirculation (c) installing mixing devices that can be operated mechanically or manually. Where no agitation is provided. Stratification in a digester may be minimised by using a horizontal-displacement digester which stimulates a plug type of flow.

In a pilot plant study in India, on the digestion of cowdung with gas recirculation was found to be almost twice the amount produced in a conventional digester.

The methane bacteria function over a pH range of 6.6 to 7.6 with an optimum near 7.0. When the rate of acid formation exceeds the rate of break down to methane, a process imbalance results in which the pH decreases, gas production falls of an the Co_2 content of the gas increases. pH control is therefore essential to ensure a high rate of methane production. Lime is commonly used to raise the pH of an anaerobic system when there is a process imbalance. Caution must be taken since excess application of lime is not advisable. Sodium bicarbonate can alternatively be used for pH adjustment.

In order to avoid a decrease in pH, sufficient alkalinity must be present to compensate for the high CO_2 content. At a 30% CO_2 content in digester gas, 1500 mg/l of alkalinity is necessary.

Volatile Acid Content :

The volatile analysis proved to be one of the important control tests for anaerobic digestion. it is commonly recognised that an increase in volatile acid concentrations is one of the first signs of an upset digester and signals the need for control before a drop in pH.

The actual effect of high volatile acid concentration on the digestion process has long been debated. One group feels that a concentration of volatile acids above 2.000 mg/l causes retardation of methane bacteria regardless of the pH maintained. Another school is of the opinion that the toxicity of volatile acids is due to lowering of pH.

Studies made by McCarty and McKinney (6) showed that

1. The decreased activity of methane bacteria observed following an increase in volatile acid concentration and subsequent neutralisation is not due to volatile acid toxicity but is associated with 'salt' toxicity.
2. Salt toxicity is associated for the most part with the type and concentration of the cation portion of alkaline materials used for neutralisation of acids.
3. Sodium salts are relatively toxic to methane bacteria when added on a slug basis and hence NaoH is a poor material for neutralisation of access volatile solids.

Organic Loading Rate and Retention Time

The quantity of gas produced in a biogas plant per day depends on the amount of waste material fed per unit volume of the digester capacity.

The recommended loading rate for standard municipal digesters is 0.48 to 1.6 kg per m^3/day and retention time can vary from 30-90 days.

Studies based on dairy cattle wastes indicate that at daily loading rate of 167 kg per m^3, a gas production of 0.04 to 0.74 m^3 per kg of raw dung fed was obtained (6). A recent study reported results on the effect of cow dung loading on gas production of a pilot-scale dung digester with a capacity of $1m^3$ and equipped with a 0.69 m^3 gas holder (6). Results of these studies are shown in Table 2.

From Table 2, it can be seen that the optimum loading rate is 24kg/m^3/day of fresh dung.

Optimum loading rate for night soil is reported as ranging from 1.04 to 2.23 kg per m^3 of digester capacity (7). Higher loading rate was adopted in towns where the mean ambient temperatures were higher. A night soil loading rate of 16kg per m^3 digester capacity per day is recommended. An average daily gas production of 0.023 to 0.034m^3 per capita was recorded for these plants.

The solids retention time represents the average time the microorganisms spend in the system and is equal to the hydraulic retention time in a completely mixed digester. The hydraulic retention time is the digester volume divided by the volume or daily feed. The usual retention time is between 20–50 days. Relation of retention time with gas production is shown in Table 3.

Nutrient Requirement :

In anaerobic digestion, a portion of the organic substrate is converted to microbial cells, while most of the remainder is stabilised by conversion to methane and CO_2. Carbon, hydrogen nitrogen and phosphorus are the major elements, required for cell growth, although trace amounts of many other elements are also required. Two of the most important nutrients for anaerobic digestion are organic carbon and nitrogen. Experience has shown that gas production can be increased by supplementing substrates that have high carbon content with substract containing nitrogen and vice versa. It has been found as a matter of practice, that it is important to maintain a C/N ratio (by weight) close to 30 to achieve an optimum rate of digestion(8). If the C/N ratio is too high, the process is limited by nitrogen availability, if it is too low, ammonia may be found in quantities large enough to be toxic to the bacterial population. C/N ratio of various waste materials is shown in Table-3.

Influent Solids Concentration :

Gas production from biogas plants is also dependent upon the concentration of solids in the influent slurry. A total solids concentration of 10-12% in the slurry corresponding to 7-g%. Volatile solids is considered optimum for gas production. Total volatile solid content of different waste materials is given in Table 4.

Quality of Raw Material

It has been observed that vegetable matter from young plants produces more gas than from the older plants and that dry vegetable matter produces more gas than green vegetable matter (9). Various authors have reported on the quantity and composition of the biogas produced from different waste materials. Typical results are shown in Table 5.

Simulating Effects of Various Materials :

The effects on biogas production of adding small amounts of different materials to cow dung are shown in Table 6.

Effect of addition of cellusosic materials to chicken manure on bio gas production (11) is shown in Table 7.

Cellulose and hemicellulose contents of cowdung before and after anaerobic degestion are shown in Table 8.

There is some evidence that the optimum C : N ratio may vary with temperature. In winter, for example, the gas production in cowdung biogas plants in India dropped to about one-third of the quantity produced during summer months (12). Gas production could be stimulated in winter, however, by adding easily digestible material, such as powdered leaves, kitchen wastes, and powdered straw, that promote the multiplication of organisms. In this experiments, gas production from 0.5 kg dung was almost double from about 17.2 litres to 31.5 litres at 7C by the addition of 200 ml of urine. It was also reported that dehydrated leaves, straw and saw dust retained the property of stimulating gas production.

Toxicity :

A number of substances, both organic and inorganic, may be inhibitory to the anaerobic process. Some of the substances include pesticides, antibiotics, heavy metals, sulphide etc. The capacity for a material to inhibit biological activity depends on the concentration. In general if a substance such as Na, K. Ca and Mg is present in low concentration, it may be stimulatory, particularly if it is needed in small amounts for biological growth. When its concentration is high, however it may become toxic.

Residues of crops that have been treated heavily with pesticides, such as DDT and other chlorinated hydrocarbons, may introduce toxic inhibitors in to the digester. Washing the residues with water will not help as these pesticides are not water soluble. A further source of toxic substances may be the excreta of animals (copper) as growth factors in their feed or as anthelminthics.

Disposal of Digester Residue :

The composition of the sludge produced by anaerobic digestion is determined by the composition of the raw material fed to the digester. It is assured that 70% of the organic constituents available is decomposed. The remaining 30% of the organic matter will be in sludge. Sludge will consist of three classes of material : original substances protected from bacterial decomposition by lignin newly synthesised bacterial cellular substances and relatively small amounts of fatty acids. Anaerobic digestion of plant residues and animal wastes conserves nutrients needed for the continued production of crops. Approximately 99% of the nitrogen in the original material will be retained in the sludge whiie 1% or less is lost in the gases evolved in the process. More than 18% of total original nitrogen in the sludge will be in the form of ammonia. Thus, as much as 18% of the original nitrogen can be lost by the handling the slurry in a way that allows loss by voltalization. To minimize ammonia nitrogen losses, digested sludge should be stored in deep lagoons or tanks that present a minimum surface area for ammonia voltalization. If plant residues are harvested and properly stored as feed-stock for anaerobic digester, many essential plant nutrients like phosphorous, potassium etc. are more efficiently utilized because they will be returned to the soil just before planting of next crop.

The major problem involves transportation of the digested slurry. One approach to this problem that avoids this difficult tasks has been reported from India (13, 14). The spend slurry is carried by a channel from the digester to a sloping filter bed, where it percolates through a 15 cm layer of compacted dry or green leaves. The slope allows the liquid to be partially decanted. The residue can then be handled as a solid or semisolid for transportation to a compost pit. The decanted liquid is then available for mixing with fresh dung to be fed to the digester.

Composition of Gas

In the conversion of carbohydrate to methane and carbon dioxide, equal volumes of each gas are produced. However, not all of the carbon dioxide produced is released as gas since it is water soluble. Carbon dioxide also reacts with hydroxylion to form bicarbonate. The concentration of bicarbonate is affected by alkalinity, temperature etc. conditions that favour bicarbonate production will increase the percentage of methane in the gas phase.

Hydroxylion is produced during deamination of amino acids. Therefore, the protein content of the substrate will significantly affect the quantity of CO_2 found as bicarbonate. The CO_2 that is associated with liquid stream as bicarbonate is reduced by increase in temperature and by decrease in pH. The retention time of the liquid in reaction process will also affect the proportion of CO_2 found in the liquid phase, digestion at shorter retention times, for a given substrate, will produce a gas with a higher methane content and a liquid phase with more carbon dioxide.

Operation & Maintenance of a Digester :

The balanced digester is one in which digestion proceeds with a minimum of control. When an imbalance does occur, the two main problems are the identification of the commencement of the unbalanced condition and the cause of the imbalance. There is no single parameter that indicate this imbalance. Increasing parameters are :

1. Volatile acid concentration and
2. Percent CO_2 in gas

Decreasing parameters are :

1. Total gas production and
2. Waste stabilization

The routine tests to be carried out are (i) pH (ii) Volatile acid content (iii) alkalinity (iv) gas production per unit of VS destroyed (v) gas consumption (vi) volatile solids in influent and effluent.

The best and most single factor of digester would be a change in pH. In an operating system, decrease in pH is associated with an increase in volatile acid concentration. Measurement of the increase in volatile acids is also a good control parameter.

The most immediate indication of impending operational problems is a significant decrease in the rate of gas production. A decrease in gas production rate may also be caused by decrease in either the digester temperature or the rate at which the feed is added. Threfore, this parameter can be used as a sure indicator of digester imbalance when temperature and loading rate are maintained constant.

The biogas plant operator lacking laboratory facilities should use a more empirical approach to digester imbalance. If a decrease in gas production is noted, the first two things to consider are the temperature and loading rate. If no significant change in temperature is noted and the feed rate is constant when a drop in pH and some toxic material in digester feed, should be suspected. In that case the first step is to add lime to treat a pH decrease to see if the gas production begins or rise. If this treatment is not successful the reason can be the presence of toxic materials. Practical remedy in such cases is to dilute the normal feed material with other digestible wastes like straw, hay, grass clippings, urine, night soil.

Finally, if all else fails and the digester becoms and remains 'stuck' the only course of action left is to empty the digester and start again.

Maintenance of the Plant :

The precautions to be taken in the maintenance of biogas digesters include.

1. Corrosion prevention by using digester tanks of wood, fibre glass, concrete, masonary brick or stoneware as animal & human wastes are corrosive before, during and after digestion. Use of plastic or stainless steel pipe lines. Coating the inside surface with corrosion-resistant paint, epoxy servicing or similar covering.
2. Avoiding use of dissimilar metals in water pipes and system components to eliminate galvenic corrosion.
3. Installation of screening device to remove large solids in any form to eliminate abrasive action on pumps and agitators.
4. Keeping all the components of the digestion system free from gas leakes to eliminate gas loss, accumulation of methane in confined areas and the introduction of air to the digester.
5. Routine inspection of all piping and metal components of the digester and handling system.

Quantity of gas Production in Anaerobic Digestion :

Typical values would be in the range of 0.4 — 0.5m^3/kg or dry volatile solids added using primarily animal manure, human waste and crop residues as the feed material, with detention time between 10 to 20 days. The methane content of the gas can be expected to be about 60% which means a methane production rate of about 0.22 to 0.3 m^3/kg of dry volatile solids digested, over an average detention time of about 15 days.

Quality of gas :

The composition of gas produced by a properly functioning anaerobic digester should be about 60-70% methane and 30-40% carban dioxide with small amount of $H_2 S^5$ hydrogen, ammonia and oxidies of nitrogen. The composition of gas is a function of the feed material. A cellulosic waste will produce approximately equal quantities of methane and carbon dioxide. A waste containing protein or fats will produce gas with a higher methane content.

The gas as produced has a heat value of 500-700 BTU/ft^3 and can be used as a fuel, for heating purposes, or for internal combustion engines.

The principal contaminants are hydrogen sulphide and CO_2 which can be reduced by (i) water scrubbing (ii) caustic scrubbing (iii) solid absorption (iv) liquid absorption and (v) pressure separation.

Water Scrubbing :

Water scrubbing is the simplest method of removing contaminants from digester gas. However, water requirements of this process are higher.

Scrubbing CO_2 from 0.2m^3 of digester gas at 20°C and pressure of 1.03 kg/cm^3 requires approx. 91.0 litres of water assuming a CO_2 content in gas of 35%.

Increased pressure reduces the water requirement but introduces corrosion problems in compressor. Further, when appreciable quantities of CO_2 are absorbed, the water generally becomes acidic.

Caustic scrubbing :

NaOH, KOH and lime are commonly used in caustic scrubbing of industrial gases that contain CO_2 and H_2S. As the solutions are subjected to CO_2 in gas stream, an irrevesible carbonate-forming reaction, occurs followed by a reversible bicarbonate forming reaction.

Absorption of CO_2 in alkaline solution is assisted by agitation. Rate of absorption is dependent on concentration of solution. With NaOH as example, the rate is most rapid at normalities of 2.5 to 3.0.

The chief disadvantage in using lime water are the difficulties in controlling solution strength and removal of large amounts of $CaCo_3$ precipitate from the mixing tank and scrubber.

If the constant time is great enough, H_2S can also be removed as caustic scrubbing.

H_2S & CO_2 can also be removed by ammonical solution, sodium phenolate etc.

Solid Absorption :

A dry gas scrubber containing iron sponge made up of ferric oxide and wood shaving can be used to economically remove H_2S from digester gas. An inlet condition of 0.2% H_2S and $0.0352 m^3$ of iron sponge will remove H_2S from approximately $2500 m^3$ of gas or remove 3.7 kg of sulphur. Regeneration involves exposing the iron sponge to air which converts the ferric sulphide formed by the scrubbing operation back to ferric oxide and elemental sulphur.

Zinc oxide is also effective in removing H_2S from digester gas. It is more expensive than iron, which can be obtained from fillings, steel cuttings and similar sources.

I.C. Engines to use Biogas :

The growing Energy crisis faced by the world has led to a keen interest in the development of non-conventional energy sources. Biogas is one of the most attractive of these sources for the following reasons :

1. It can be produced from renewable sources like plants, cowdung and minicipal wastes.
2. It can be used to generate energy in the rural areas, which are traditionally short of modern forms of energy.

Biogas Digesters of several types have been developed-batch types, steady flow types, fixed dome types, floating dome types etc. They can be made large or small depending on raw material availability.

The biogas generated can be used for power production by the following types of internal combustion Engines :

1. Spark Ignited Engines
   (i) Naturally aspirated
   (ii) Supercharged.
2. Dual Fuel Engines
   (i) Naturally aspirated
   (ii) Supercharged.

Biogas is a mixture of 55-70 per cent by volume of methane, 25-45 per cent by volume CO_2 with traces of hydrogen and hydrogen sulphide. The principal properties of biogas are compared below with pure methane and butane :

	Density (KG/NM)	Lower Cal. value (K.cal/NM^3)	Stoich. Air Req. (NM^3air/ NM^3 gas)	Ignition Limits (per cent Volume in mix)	Methane No.
Butane	2.6	29,500	32	1.5-8.5	10
Methane	0.717	8,550	9.5	5-15	100
Biogas	1.1	5000-6000	5-7	3-9	130

The properties of biogas are seen to be mainly dependent on its methane content. It has wide ignition limits and high knock resistance, which are advantageous in both SI and Dual Fuel Engines.

Removal of the CO_2 from biogas can be done by simple methods like passing it through lime water or other commercially available absorbents. This improves its calorific value but lowers its knock resistance.

Removal of H_2S and moisture present in the biogas is highly desirable since they can corrode engine parts.

General Advantages of gas Engines :

Gas engines have the following advantages :

1. Smoke emissions and engine deposits are very low.
2. Lubricating oil consumption is low due to absence of contamination.

Safety :

However, gases have to be more carefully stored and handled than liquid fuels. The following safety precautions have to be observed :

1. Non-return values and flame traps have to be provided between gas tanks and engines.
2. Crank cases of gas engines have to be vented or continuously evacuated.

Spark Ignited Gas Engines :

These engines are available upto 7000 HP, the larger ones running at slow speeds of 250-300 rpm.

The gas and air quantities are simultaneously regulated to maintain a near constant mixture ratio.

SI engines using biogas can use high compression ratios upto 12.5. Hence their efficiency is high. Larger engine sizes and supercharging make them even more efficient.

Biogas SI engines can be supercharged to increase the output and make them more compact. If a turbo supercharger is used the air pressure varies with the engine speed. Hence in such engines a gas pressure regulator is also used to adjust the gas pressure and keep it in step with the air pressure.

Ignition Systems :

SI gas engines, operating with high compression ratios require high sparking voltages, 14-16 KV. Large engines of this type are provided with individual induction coils and shielded cables to avoid fire hazard. Spark plugs with platinum electrodes have 4-5 times the life of normal plugs.

Exhaust Emissions :

Most gases are clean burning and Methane no exception. Hence biogas SI engines are environmentally even better than gasolene engines.

Choice :

SI Engines are the preferred choice for biogas when the gas supply is adequate and reliable. For the same output, the initial and operating costs are lower than the Dual Fuel type to be described.

Conversion of Small Existing SI Engines in Biogas Operation :

For small scale rural application, existing SI engines can be converted to work on biogas. The gasolene carburetor should also be included. The engine should be started on gasolene and after some minutes the gas supply should be opened and the petrol supply cut off.

In converting and employing such small engines for biogas operation it is important to incorporate the safety precaution outlined before.

Dual Fuel Engine :

Biogas, as a high knock resistant fuel, is a poor diesel engine fuel. Also the difficulties of injecting a gas under high pressure into the cylinder are great. Hence, the dual fuel system has become the most widely accepted way of employing biogas in diesel engines.

This system enables the engine to be operated as a pure diesel engine or as a dual fuel engine with minimum pilot diesel oil injection. In large engines, specially manufactured for this purpose, this quantity is as little as 7 per cent of the full load diesel flow rate. In normal diesel engines, this ranges from 15-20 per cent, as the pump is not designed for this purpose. The air and gas are mixed in the manifold, compressed in the cylinder and ignited by a pilot spray of diesel oil. Upto 80 per cent of the engine energy requirement can come from the gas.

Existing agricultural diesel engines can be easily converted to work on this principle. If the engine operates on steady load, as a pumpset for example, all that the necessary is a small pipe to convey the gas to the inlet manifold and a value to control its flow rate. The engine should be started on diesel, then gas should be gradually introduced and the flow rate increased. Simultaneously the diesel flow rate should be reduced. In a governed engine this is done automatically by the governor. The gas flow should be adjusted to be just below the knock or misfine limit. In a variable speed diesel engine a control mechanism, a regulator for gas and diesel quantities should be employed.

Dual Fuel gas engines are highly flexible and can run on diesel oil alone and also over a wide range of gas-diesel ratios. Existing diesel engines can be easily converted to work on this system.

The thermal efficiency of Dual Fuel engines is lower than diesel efficiency at part loads but equal or even higher at high loads. Due to their high air utilisation they can deliver a higher power output than on diesel operation. But this shouid be done only if the engine is of robust construction with good factors of safety. Smoke emissions are drastically reduced by gas induction.

Large engines of this type are also available in super-charged versions. The thermal efficiency and power output of such engines are greatly increased by supercharging.

Biogas Engines for Energy Production :

Upto now, biogas has been mainly used in the rural areas for cooking and running small engines. However, biogas can be even more valuable if it is used systematically for regular power production in rural areas. For this purpose the biomass-biogas-biogas engine routs is the best. The layout of such a system is shown schmatically. Such a system involves cultivating of some high yielding biomass species, phased harvesting and slurrying, biogas digesters, strorage tanks, gas engines and electrical generators. The products of the system are electrical power, cooking gas and organic fertiliser.

Gas engines are the ideal power plants for this purpose. If combined with exhaust heat recover units the system can highly flexible and economic.

Conclusion :

Basically two types of engines are available for biogas operation, the spark-ignited variety and the Dual Fuel variety. Existing gasolene and diesel engines can be converted to work on this gas. Engine deposition, lubrication oil comsumption and smoke omissions are drastically reduced. However, the gas to be cleaned of H_2S and water before it is admitted to the engine. Also elementary safety precaution have to be adopted.

Biogas engines, to summarise, hold out great promise to the rural areas for power generation that is dependable and based on locally available raw materials.

TABLE—1

Effect of Temperature on Biogas Generation

Temp (C)	M^3 gas produced/Kg. wet dung
15	0.032
20	0 049
25	0.061
30	0.087
35	0.100

TABLE—2

Effect of Dung Loading on the gas Production in a Pilot Scale Dung Digester

Fresh dung loaded kg/m^3/day	Volatile solids loaded kg/m^3/day	Detention time (days)	Vol. of gas produced (m^3)	Gas produced per unit WT of V s destroyed (m^3/kg)
8.0	1.17	50	0.22	0.88
16.0	2.40	25	0.42	0.82
24.0	3.76	17	0.52	0.97
32.0	5.29	12	0.47	0.63

TABLE—3

Retention of Retention time with gas Production on a Sewage Sludge Digester

Retention time (days)	Gas production (m^2/m^3 cap dig/day
30	0.40
20	0.60
15	0.80
12	0.95
10	1.15

TABLE—3-A

C/N Ratio by WT of various Waste Materials (Dry WT Basi)

Material	N (%)	C/N
ANIMAL WASTES		
Blood	10-14	3.0
Urine	15-18	0.8
Cow manure	1 7	25
Farm yard manure	2.15	18
Poultry manure	7.10	2
Night soil	5.5—6.5	14
PLANT WASTES		
Raw saw dust	0.1	511
Young grass	4.0	12
Wheat straw	0 3	128
Cut straw	1.1	48
Grass cilpping (Mix)	2.4	19
HOUSEHOLD WASTES		
Raw garbage	2 2	25
Potato tops	1.5	25
Paper	Nil	—

TABLE—4

Characteristics of certain Waste Materials

Waste material	%
COW DUNG (WET WG BASIS)	
Total solids	20-25
Volatile solids	10-15
NIGHT SOIL	
Moisture	95
Ash	1.6
Org. Matter	3.4
Nitrogen	0.57
AGRICULTURAL WASTES (DRY)	% Vol. Solids
Groundnut shell	30
Bagasse	40
Soyabeen tops	50
Rice husk	10

TABLE—5

Yield of Biogas from Various Materials

Raw Materials	Biogas m^3/kg	Temp°C	CH_4 Content	Detention time
Cattle manure	0.23-	11.1-	—	—
	0.50	31.1	—	—
Forage leaves	0.5	—	—	29
Sugar beet leave	0.5	—	—	14
Algae	0.32	45—50	—	11-20
Night soil	0.38	20-. 6.2	—	21
Poultry manure	0.56	50.6	69.0	9
Chicken manure	0.31	37 3	60	30
Swine manure	1.02	34.6	68	20

TABLE—6

Biogas Production from Anaerobic Fermentation at Room Temperature of Mixtures of Cow Dung and Agricultural Wastes

Sr. No.	Raw Material	Biogas Production per Unit WT of Dry Solids %		Gas Composition %	
		At the end of 24 days	At the end of 80 days	Ch_u	CO_2
		m^3/kg			
1.	Cow dung	0.063	0.21	60.0	34.4
2.	Cow dung + 1% cellulose	0.084	0.21	52.8	44 0
3.	Cow dung + 0.4% casein	0.087	0.22	64.0	32.0
4.	Cow dung + 20% dry	0.081	0.22	68.0	28.0
5.	Cow dung + 24% fresh leguminous leaves	0.063	0.20	61.6	32.0
6.	Cow dung + 1.2% (oil cake)	0.063	0.20	67.7	30.4

TABLE—7

Affect of addition of various Materials on Biogas Generation using Chicken Manure

No.	Material	Production	Cu. ft. up vol. of gas/mat added	% CH_u
1.	Chicken manure	100	5	59.8
2.	—do— + Paper pulp	31/69	7.8	60.0
3.	—do— + Newspaper	50/50	4.1	66.1
4.	—do— + Grass clippings	50/50	5.9	68.1

TABLE—8

Cellulose and Hemicellulose content of Cow Dung before and after Anaerobic Digestion

No.	System	Before digestion		After digestion	
		% cellulose	% hemi cellulose	% cellu-lose	% hemi cellulose
1.	Cow dung	28.77	24.29	23 05	12.27
2,	Cow dung + wheat straw	33.63	26.95	24.22	17.17
3.	Cow dung + Ground nut shell	33 41	25.58	27.74	13.51
4.	Cow dung + bagasse	34.56	25 81	26.38	17.80

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Bee Keeping

Introduction : Honey is one of the most nourishing foods in the world and its nutritive value is rated very high. It is known to man from very ancient times. And yet no effort was made to tame the bees and no one ever thought of keeping bees as pets and getting a regular crop of honey from the beehives. It is due to the effort of Huber that new houses for bees were designed and bee keeping and honey extraction are now learnt as art and science. Bee keeping nowadays has been so perfected that any one with a little training can do it and earn a livelihood out of it. Its importance is increasing day by day due to the usefulness of bees for pollination of seeds and fruit crops. In many developing countries, farmers hire beehives during the flowering period, specially for this purpose, and have obtained a production increase of upto 25%. Many uses of bees-wax have also been developed these days and it has become a very expensive item, being the base of cosmetic and polish industries.

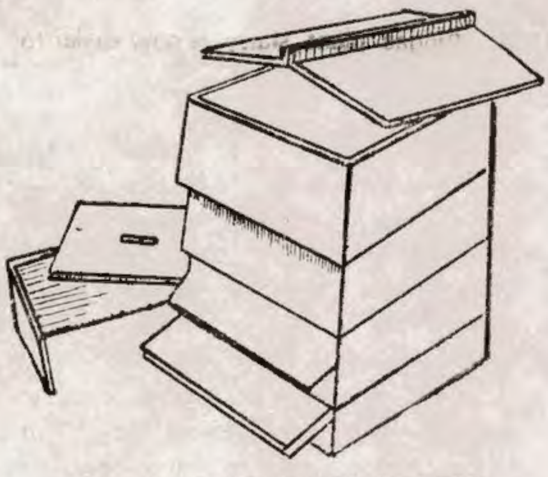
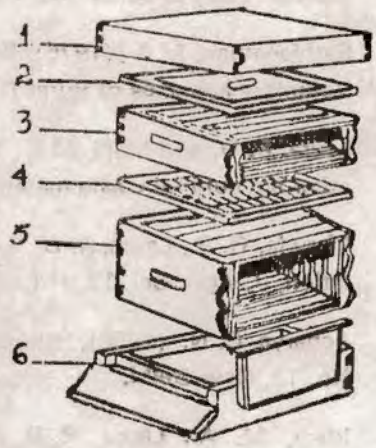


FIG. 1 : NEW HOUSE OF BESS

Equipment : The minimum equipment required to start this small industry includes the beehive box, smoker, and extractor. A hive box is usually made of gamhar or teak wood A complete box contains several separable parts termed as top cover, chamber, and floor board. There are two chambers one for honey called super chamber and the other for brood rearing called brood chamber. The chamber has several movable frames numbering 8 to 10 each containing a comb parallel to one another. Fig. 2 and 4.



1. Roof 2. Inner Cover 3. Supper Chamber
4. Partition Wall 5. Brood Chamber 6. Floor Board

FIG. 2 : COMPARTMENT OF BEE'S NEW HOUSE

FIG. 3 : FRAME CONTAINING HONEY

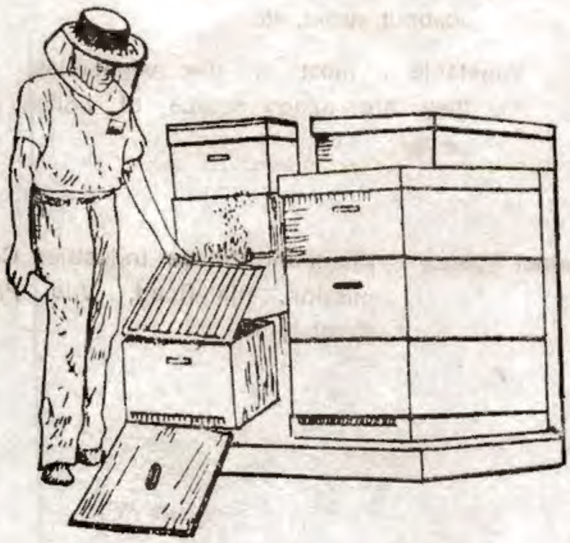


FIG. 4 : CORRECT METHOD OF INSPECTING THE BEE'S HOUSE

A smoke producing equipment, Fig. 6. is used at the time of handling bees so that they may not sting. An extractor, Fig. 5, is used for extracting honey from the upper comb frames.

Honey is extracted only in honey flow periods which fluctuate according to agro-climatic and floral conditions of the region.

FIG. 5 : EQUIPMENT USED FOR EXTRACTING HONEY FROM BEEHIVES

FIG. 6: SMOKE PRODUCING EQUIPMENT

Type of bees : A bee colony is a complete biological unit composed of thousands of worker bees, hundreds of drones and only one queen. In nature, they dwell in the dark on wax combs, the cells of which contain eggs, larvae and pupae, called brood. The brood is in the form of a sphere in the lower part of the comb ; on the top and on each side is the bin of stored pollen and beyond this honey is stored.

The workers compose the bulk of the population and their main task is to look after the colony in all respects. The drone or male bees are required to fertilise the virgin queen. The queen is the only fully developed female and is in fact an egg-laying machine. She never goes out of the hive after mating, except at the time of swarming or laying the foundation of another colony.

Management includes the adjustment and fulfilling of the colony's demands. This can only be fulfilled, when the bees are frequently observed. The colonies should be kept clean and strong to prevent from attack of disease or enemy. Before absconding, the bees stop their activities and the queen suspends egg laying. Swarming takes place only in the favourable season, when there is abundance of food supply. In lean seasons, when there is dearth of natural bee-flora, it becomes essential to feed bee-colonies with sugar solution. The queen should be renewed yearly by replacing the old ores.

Bee-flora : All plants do not provide nectaries to bees for honey ; there are only some selected plants which they approach for nectaries, pollen or both. These plants are called bee-flora. Some of the important bee-flora are the following ornamental plants :

Flowers ; corn flower, coral creeper, cosmos, poppy, portula, sun-flower, zinnia, etc.

Fruits : banana, berries, citrus, apples, pears, cherry, guava, jamun, lichi, etc.

Crops : rape mustard, taramira, toria, berseem, maize, til, jute, sorghum, etc.

Trees : tamarind, drumstick, sandal, sisoo, soapnut, neem, etc.

Vegetable : most of the vegetables, but they are minor source of pollen and nectary.

Contact Agency : Khadi and Village Industries Commission, Irla Road, Vile Parle, Bombay-56.

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"You will do foolish things, but do them with enthusiasm."

— Collette

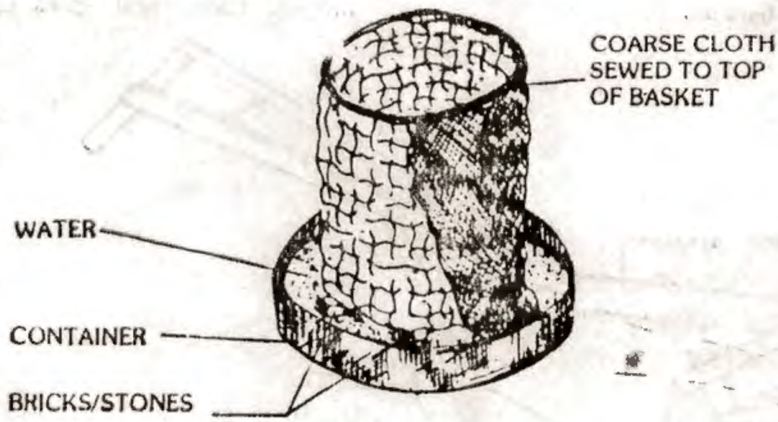
Bamboo Iceless Refrigerator

A refrigerator made of bamboo or wood can be used for storing vegetables, milk and perishable items.

A cylindrical basket is prepared with bamboo or slender wood with an open weave. The basket should be provided with a loose fitting cover made of coarse jute type cloth. The jute cloth should be sewn around the rim of the basket and allowed to hang loose around the bottom exceeding the length of the basket. This part of the jute cloth can then touch container which should then be filled with water The container would need to be placed carefully on the water when it is placed in the container. The basket should be put in a square or round container which could be fabricated from metal or clay. Four or five bricks or stones' may be placed in a circle inside the bricks to see that it balances evenly. The size of the refrigerator would depend upon the family's requirements.

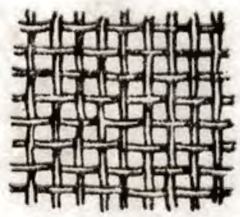
Food items are then kept in the basket which is covered with a loose fitting wet cloth. The cover would need to dampened periodically.

It is important to note that the basket should not be in the water but only the cloth cover should hang down into the water.



COMPLETE UNIT

LOOSE FITTING LID



OPEN WEAVE OF BAMBOO OR OTHER SLENDER WOOD

This can easily be fabricated in villages.

Contact Agency : Thailand Programme Office
UNICEF/EAPRO
P.O. BOX 2-154
Bangkok 10200
Thailand.

Animal Drawn Potato Digger

Introduction : There was a great need for designing a mechanical potato digger, drawn by bullocks to overcome the time-consuming and monotonous process of harvesting potatoes and other root crops like shakarqand (sweat potatoes) etc., which involve hard manual labour with tools like spades, hoes, etc. The potato digger of this design helps in reducing labour costs, ensures quicker operation, and increases the margin of profit for the growers.

The principle on which the potato digger has been designed is to shear the soil in the horizontal plane below the depth to which potato tubers are formed to lift the soil along with the tuber on a grading frame through which the tubers would be separated from the soil and left at the rear side of the digger. The design ensures simple construction, minimum damage to the tubers, clog-free speration, placement of the tubers on surface of the soil and desirable draft.

Method of construction : The digger consists of four basic parts, viz. (i) share (Fig. 2), (ii) grading frame or platform (Fig. 1), (iii) goose neck short settle beam. (Fig. 1), (iv) shaker wheel, with legs under the grading platform. (Fig. 3).

(i) *The share* is 43 cm. wide and 38 cm, long, oval in shape for digging and uprooting the tubers.

(ii) *The grading frame or platform* consists of M. S. rod of 1.9 cm. size welded to a bar adjacent to the share and has sheet metal guards on both sides to guide the material passing over to the sides. It is a hinged frame and goes up and down due to the falling action of the shaker wheel.

(iii) *The shaker wheel* is a 26 cm. dia, and 6 cm. wide wheel having 5 curved legs of 9 cm. each, situated under the middle of the grading frame. The whole grading frame drops by 9 cm. imparting force to the soil having tubers. Due to the rapid falling action of the grading frame the tubers are separated from the soil.

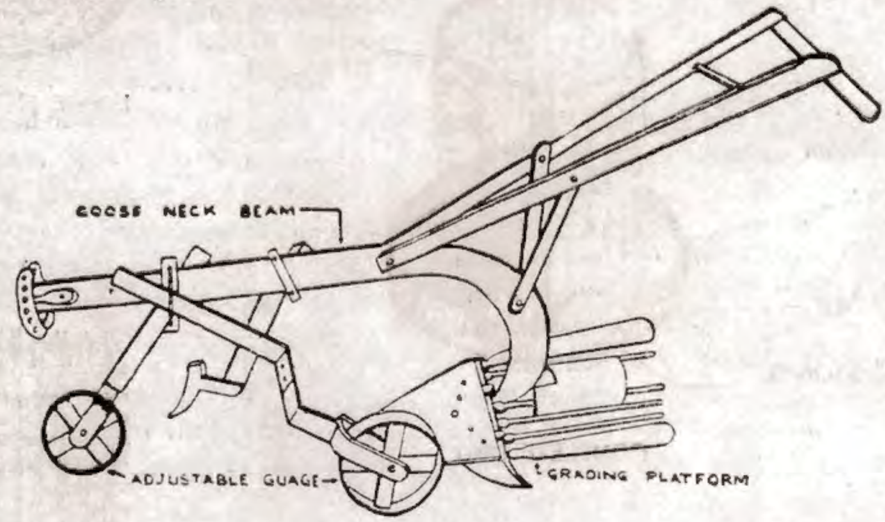


FIG. 1

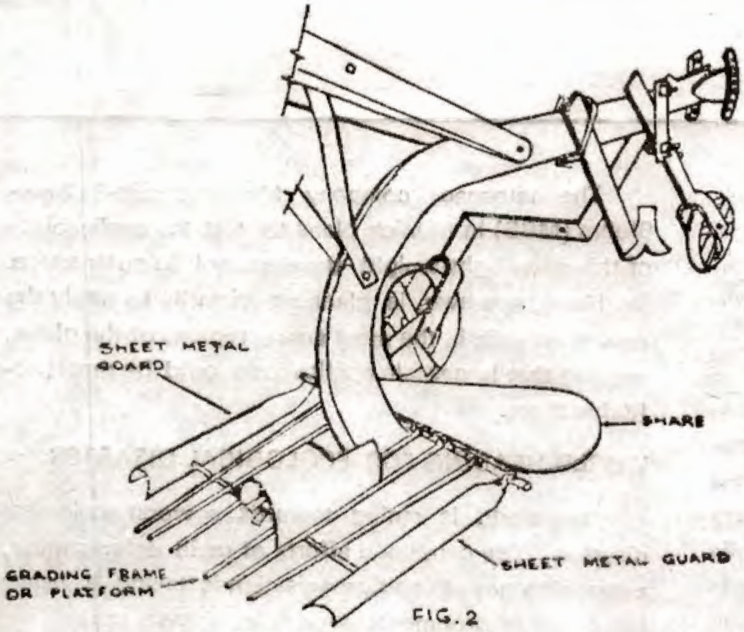


FIG. 2

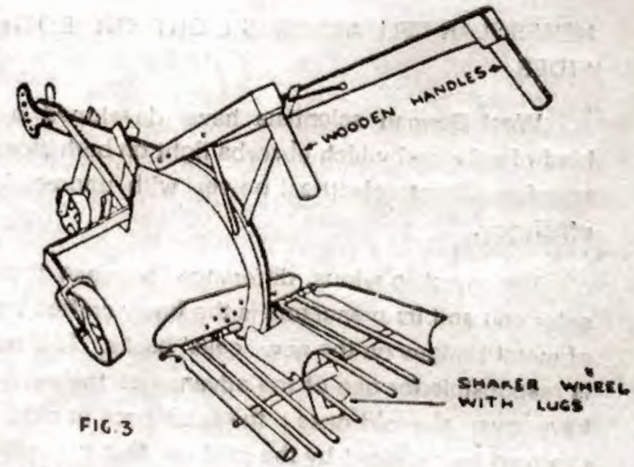


FIG. 3

(iv) *Accessories* consist of the beam, which is goose neck type, gauge wheel and small shovel. The goose neek beam is made of M. S. flat of 7.5 cm. × 1.5 cm. and about 130 cm. The share is fixed on the lower end of the beam and the upper end has a nautical hitch for depth control. With the beam, there are two wooden handles for operating and balancing the diggers. Also, there are two gauge wheels attached to the beam. The depth of the gauge wheel and their distances from each other are adjustable. One of them moves over the ridge and the other in the furrow which provides balance and assists in depth control. A small shovel-like structure is also fixed right in front of the share to dig and loosen the crown of the ridge with the weeds and potato plants to avoid hinderance to the soil with creepers and weeds sticking to and around the beam.

How to operate : A pair of bullocks and two persons are required to operate the potato digger. The necessary adjustments to gauge wheel and vertical hitch are done, according to the requirements. The digger digs the complete ridge upto the depth of the tuber formation. The oval shaped share cuts and lifts up the soil along with the tubers on the grading frame which has a jerking action due to the rolling wheels (shaker) having legs about 9 cm. long. Due to the jerks given by the falling grading frame, the tubers are separated from the soil lumps and fall behind. Later the patatoes are picked up in baskets.

Performance : Depth of the cut .... 15-20 cm.
Width of the cut ... 50 cm.
Total draft .... 140-200 kg

Contact Agency : Allahabad Agricultural Institute, Naini Allahabad, U.P.

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News & Views

NEW SOLAR CELL ABSORBS LIGHT ON BOTH SIDES

West German scientists have developed a new kind of solar cell which absorbs light on both sides and transforms it into electrical power with unprecedented efficiency.

The most obvious difference between the new solar cell and its precursors is the finely crafted pattern of metal bridges on the new cells' backs. This feature is responsible for one of the advantages the new cells have over the old ones ; the solid back in older cells can now be replaced by the grid so that the cell can absorb light not only on one but on both sides and transform it to electrical power.

According to Dr. Rudolf Hezel of the Institute of Materials Science at the University Erlangen-Nurnberg, the new solar cell can be manufactured at a low cost, lasts longer, weighs less, and is flexible. Due to its open back, it leads to unprecedented efficiency rates. While traditional cells transform less than 15 per cent of the incident light into electrical energy, the new type of cells has already achieved efficiency rates ranging between 20 and 24 per cent. Experts believe that the performance can be improved even further, because of its double-face design which will help it to process both incident and reflected light. This means that direct sunlight can easily be diverted to the back side.

The cell also efficiently uses "diffused light" present in overcast weather and occurring most frequently in median latitudes. The layer of crystalline silicon that transforms light to electrical energy is no thicker than a human hair and carries an insulating silicon nitride coating. This design reduces the cost of materials by 50 per cent. The silicon nitride layers also protects the cells from humidity, thus increasing longevity.

The aerospace company Messerschmitt-Bolkow-Blohm (MBB) in Munich plans to test the applicability of this new light-weight development in outer space. Dr. Hezel, however, is planning primarily to apply the new solar cells in the most sunny regions of the globe, arguing that largescale application would be most profitable there.

WORLD HEADING FOR ECOLOGICAL DISASTER

The world is racing towards a worst ecological disaster. The combined efforts of rapid deforestation, population growth and urbanisation is taking a heavy toll of the environmental wealth, ecologists say.

Already, more than 625 million people mostly in the Third World are breathing air contaminate with carbon and nitrogen dioxide gases, says a report of the United Nations Environment programme (UNEP).

The UNEP report, based on a survey conducted in 69 countries over a period of ten to fifteen years says eight cities have been marked with the highest levels of sulphur dioxide.

Five of the eight cities are in the developing world : Shenyang, Tehran, Seoul, Rio De Janerio and Beijing.

The rest are Milan, Paris and Madrid, Tokyo, Hongkong, Shanghai, New York, London and Athens have been bracketed in the midrange category.

The report states that 10 percent of the world rivers are polluted, with the Ganga heading the list.

Rapid industrialisation and population growth is expected to pollute more rivers in countries such as Brazil, Mexico, China, Indonesia and Nigeria.

Tropical forests are shrinking at a rate of 27 million acres a year, top soil being lost at the rate of 26 million tonnes a year.

New deserts are being created at the rate of 13 million acres a year and about half of the world's irrigated land is in danger, says the world population report, published by another United Nations agency.

The report says all this is happening because of rapid deforestation in the Third World which itself is an attempt to find new land and increase food production to meet the needs of their population growth.

The tropical rain forests-home to more than half the world's plant and animal species are disappearing at the rate of 20 hectares a minute, according to the World Wide Fund. (Formerly known as World Wild-life Fund).

The Washington-based World Watch Institute also depicts a grim scenario about the earth's physical conditions in its report entitled state of the world 1988.

The World Watch report says "the earth's forests are shrinking, its deserts are expanding and its soils are eroding."

Each year thousnads of plant and animal species disappear, many before they are named or catalogued.

Raising concern about the thinning of the ozone layer in the upper atmospheric surface and the rising temperature of the earth, it warns governments that such developments are posing a threat of unpredictable magnitude to all of the systems that support life on earth.

The UNEP study on global warming forecasts and increase in global temperature by 4.5 degree celsius by 2000.

This warming could raise sea levels everywhere by more than two metres threatening one-third of the world's population living within 60 Km. of coastlines. This could even wipe out the whole of the Maldives Archipelago.

A rise of less than one meter in sea levels could destroy 27 percent of Bangladesh.

Egypt could loss 20 percent of its productive land and the united States, between 50 and 80 percent of its coastal wetlands.

Apart from raising sea levels, global warning cause serious damage to agriculture. Wheat production would have to move north where depleted soils could result in falling crop outputs. The production of rice would also fall due to high temperatures.

POT TRAINING HELPS TREES IN THE NURSERY GROW TALL.

A Scottish company is making a new kind of plant pot that could revolutionise commerical forestry and horticulture. The new pots, called Rootrainers, help to produce a plant that is better able to survive the shock of transplantation, reports "New Scientist".

Rootrainers are moulded plastic sheets that fold to form a line of four "pots", supported a few centimetres above the ground. Each pot has a large drainage hole at the bottom and a series of parallel grooves running down the sides.

When a root emerges through the drainage hole, it dries out. This so-called "air pruning" kills the growing tip. In response, the plant produces more roots, which tend to grow out towards the edge of the container. "There, the grooves force the roots straight down and through the drainage hole, encouraging the growth of yet more roots. Cuttings and seeds grown in trays or in open ground often suffer considerable damage to their roots when they are transplanted. It takes them time to recover, and many die.

The planting season is almost restricted to times when the plant is almost dormant. Conventional containers can diminish root damage, and extend the planting season, but create different problems. The roots tend to circle around inside the pot and grow into "root balls". As a result, the transplanted seedling is not securely anchored.

Rootrainers produce a seedling with a good growth of roots that point straight down. When the time comes to plant out the seedling, the folded plastic sheet can be open, like a book, to release the seedlings, each with a firm plug of roots. Because the roots are straight, they grow into the soil and anchor the plant firmly. And because they are almost undamaged, the plants grow guickly.

The new pots were invented by Henry Spencer, a Canadian. Some people feel that Rootrainers can be used to grow cuttings of ornamental shrubs. Amateur gardeners too are showing interest in Rootrainers, especially for plants that resent being moved,like sweet pea and sweet corn.

NOVEL WAY OF CONTROLLING AIR POLLUTION

Indian scientists have found a novel way of controlling air pollution—by growing some traditional Indian trees that act as an effective screen against airborne particles.

Scientists at the National Botanical Research Institute (NBRI), Lucknow, have identified some 50 pollution-tolerant plant species, which when grown in heavily-polluted areas can act as "bio indicators" of air pollution and check it.

The species include bougainvillea, argemone, azadirachta indica or "neem", the date palm and local varieties of "bar", "Ashok" and "peepal".

In extensive surveys in and around thermal power stations, industrial complexes and other heavily polluted areas of U.P. and some selected areas of Delhi, the NBRI scientists found that these species reduced the overall movement of particulate matter by about 75%.

A comparative study of some species collected from healthy and polluted environments showad that there were some significant differences in the leaves, especially in the cuticle and epidermis, the two outermost layers in leaves. These modified characters, among others, could be used to detect pollution

NERI has released a list of 50 species, that includes 35 trees, 12 shrubs and three herbs, to both Governmental and non-Governmental organisations for use.

BIOGAS FOR COTTON SPINNING MILLS

Willow dust, a waste from cotton spinning mills that is used as a feedstock has successfully been tapped as an alternative to produce biogas by large-size plants.

The new, improved technology and support facilities provide an economical and efficient method to produce a sizeable quantity of biogas and organic manure. In addition, it helps to solve the problem of pollution, and disposal of huge qnantities of willow dust, a waste churned out daily by cotton spinning mills, according to a release from the Department of Non-Conventional Energy Sources (DNES).

DNES, through its Biogas Researeh Centre at the College of Technology and Agriculture Engineering, Udaipur, has designed and set up such a plant at Udaipur, Cotton Mills, in the city. The biogas plant has got a capacity to produce 20 cu. mt. of gas per day.

The technology has several innovative and beneficial features in terms of quantity of gas generated, better quality manure, and reduction in the duration of slurry drying up as manure to five days compared to 10 days in the case of dung based slurry. The plant also provides for self-loading and unloading facility systems to separate the water from the slurry and its re-use for filling the plant.

The Udaipur Cotton Mills produces 125 kgs. of willow dust per day of which 100 kgs. are adequate to operate the plant. The gas produced from the plant is equivalent to 80 kgs. of wood equivalent per day. The production of dry manure is 2.5 tonnes per month valued at Rs. 1,250/–. The slurry is a rich manure as it contains 1.5 to 1.7 per cent nitrogen.

The plant is nine times more economical as it provides for cost savings incurred by textile mills on lifting, transporting and dumping the willow dust at distant places and the big chunk of land required for such disposal. The traditional method of disposal of willow dust is unhygienic, polutes the environment through the foul smell that is emitted as the willow dust takes one year to decompose into organic manure.

The plant is quite economical since its capital cost is only about Rs. 90,000/-.

Dr. Maheshwar Dayal, Secretary, DNES, has expressed the view that most of tha cotton spinning mills in the country can set up such biogas plants and reap benefits of the new technology developed by indigenous efforts. A number of units under the National Textile Corporation have evinced keen interest in setting up of such plants. The technology developed at Udaipur is readily available almost free of cost for transfer to users.

DISTILLING SEA WATER THROUGH SOLAR ENERGY

A new method of distilling sea or brackish water through solar energy to make it potable or for use in leadacid batteries, has been developed by the Space Application Centre, Ahmedabad.

The SAC Director, said that by employing the technology and principles of operation of solar cookers and solar water heaters using the flat plate solar energy collectors. a unit comprising an insulator, evaporator, condenser and distilled water outlet has been developed.

The technique for distilling water was based on the permise that on a sunny day, one square metre of exposed water in a tank loses about four litres of water through evaporation. Since the evaporation occurred at a low temperature, if a unit was properly engineered, at least three litres of distilled water could be procured for every square metre of area exposed.

At present the centre was distilling about six litres of water per day, which was free from all impurities.

The material required for the construction of the unit is easily available.

The new technique could be useful in several parts of the country where fair weather prevailed, especially northern Gujarat, Rajasthan, northern parts of Karnataka, Andhra Pradesh and Tamil Nadu and coastal areas.

MANY USES OF TANNERY EFFLUENTS

A recent study conducted in Madurai district of Tamil Nadu indicates that treated industrial effiuents from tannery units can be used to raise good fodder crops.

The study, conducted by the Agriculture College and Research Institute of the Tamil Nadu Agriculture University, found that while the quality of well water near the pollution source deteriorated, the effects of treated effluents were positive on the soil quality.

A pot culture experiment was conducted with a test crop of ragi in two soil series—Irugur and Palathurai—which occupy major areas in Dindigul Taluk of Madurai district.

The crop was treated at four irrigational levels—with tap water, 25 per cent tannery effluent, 50 per cent tannery effluent and 100 per cent tannery effluent. The crop was also treated with varying percentage of gypsum added to the effluents.

The study revealed that irrigation with increased concentration of effluent significantly increased soil pH, electrical conductivity, organic carbon and other minerals.

Irrigation with 25 per cent effluent along with addition of gypsum was found to be the best in recoding the highest straw yield.

Irrigation with increasing concentration of effluent increased nitrogen, phosphorus and sodium contents. Irrigation with 25 and 50 per cent effluent influenced the nutrient uptake by ragi straw.

Based on findings of the study, researchers suggest that irrigation with water having 25 per cent of tannery effluent could be used for raising good ragi crop. Similarly irrigation with 50 per cent effluent content and with treated effluent only could also give luxuriant foliage growth in ragi crop. Tannery effluent can also be used as a profitable irrigation medium for growing grasses like Giant Napier, which have proved a success under sewage irrigation.

The application of gypsum followed by pressmud also proved effective in increasing available nutrient status of the soil and plants.

ELECTRIC WATER DIVINER

Farmers will soon be able to monitor the effectiveness of irrigation schemes using a new probe developed by scientists in Australia. The probe sends an electric pulse down a wire that the farmer inserts into the soil. The time that it takes the pulse to travel down to the end of the wire and back depends on the amount of water surrounding the wire.

Soil is not the only material that the probe can test. For example, surveyors can use it to check the water content of concrete structures or to trace and monitor leaks from pipes.

The electric field from the pulse leaks into the surrounding material. Any molecules that can be polarised align themselves with the passing field and so slow the pulse down. Water polarises much more easily than most materials, so the speed at which the pulse travels through the wire will depend largely on the amount of moisture in the soil surrounding it.

The probe, developed by researchers at the Commonwealth Scientific and Industrial Research Organisation in Melbourne comes in two forms. One has three metal spikes, like a fork, and the other has a single spike and lies on top of the material.

'JALTRIPTI'—A NEW DEVICE FOR DESERT IRRIGATION

Scientists at the Regional Research Station, Central Arid Zone Research Institute. Bikaner, Rajasthan, have developed 'Jaltripti'—a new irrigation device for the arid and semi-arid lands of the country.

Jaltripti is a 30-cm-high, double-walled earthen pot, which can be easily made on a potter's wheel. The diameters of the outer and inner pots are 25 cm and 15 cm respectively at the top, and 18 cm and 12 cm respectivly at the base. The dimensions of the inner pot are slightly bigger than those of a polythene bag used for raising plants in the nursery.

Both pots are joined at the base. The external side of the outer pot is made impervious with the help of paint, cement or coaltar. The cost of manufacture comes to approximatery Rs. 5 per unit, bringing the device within the reach of small and marginal farmers.

The labour-saving device is fixed in such a way that the brim of the outer pot is on level with the field surface. A tree sapling along with the soil of the original nursery is planted in the inner pot. Water is filled in the space in between the pots.

The soil moisture tension and the root pressure of the sapling inside together create a suction force that draws moisture towards the device from neighbouring high-moisture zones in the soil. The micropores present in the walls of the earthen pots, do not permit the water to flow freely, but allow only its gradual seepage in the direction in which suction develops. The paint on the outer side of the device prevents outward seepage of the moisture. Water can be refilled in the space between the two pots after a week or a fortnight, depending on the size of the pot and the season.

Jaltripti promotes faster seedling growth and reduces wilting and transplantation shocks. It ensures constant moisture supply to the saplings, leading to better growth. It also considerably reduces the frequency of irrigation and cheeks percolation, seepage and evaporation of the water.

The new irrigation device helps in regulated release of fertilisers, insecticides and pesticides to the soil from the water to which they are added and minimises weed infestation inside the pot. It can aid in the afforestation of excessively water-logged, saline or alkaline soils and holds promise in stabilisation of sand dunes.

Several experiments have been conducted on Jaltripti, using two-and-a-half-month-old "ber" seedlings which were transplanted in May and observed upto the end of August. Plantlets introduced into the device recorded 85.7 per cent increase in height and 78.1 per cent increase in diameter, compared to conventionally pianted sedlings which showed 17.9 per cent increase in height and 55 per cent increase in diameter only. The root length, and fresh and dry weights of plantlets grown in the pots were higher than those of conventional plantings.

BIOGAS FROM IPOMOEA STEMS

Stems of the common herb, Ipomoea fistulosa which are often discarded into compost pits or burnt in the open air, could be used to generate biogas, recent research shows.

After extensive tests and analysis, scientists at the Department of Chemical Engineering, University of Roorkee, showed that stems of Ipomoea fistulosa, when maintained under neutral pH conditions, produced more biogas than cattle dung.

Using different ratios of Ipomoea stems and cattle dung, they found that a mixture containing 75 per cent cattle dung and 25 per cent plant stems, produced the maximum quantity of methane—449 litres per kilogram of volatile solids.

A digester containing only Ipomoea stems, maintained at a constant neutral pH, produced 555 litres of biogas per kg of volatile solids. the scientists S. K. Sharma, J. S. Saini, I. M. Mishra and M. P. Sharma said, reporting their findings in the journal "Biological Wastes".

As the Ipomoea stems have a low content of lignin, a higher quantity of cellulose is available for bacterial degradation, compared to cowdung. The carbon : nitrogen ratio was also found to be higher in Ipomoea stems, compared to cattle dung and effluent slurry which served as a control. The stems also had the highest solubility in hot water and a mixture of ethanol and benzene.

The team also studied whether the size of the stem pieces affected biogas production. The scientists found that the highest methane yield was obtained when 0.4 mm-long pieces were used.

The findings suggest a useful and alternate source of energy for rural areas.

SUPER SOLAR CELLS

Sunlight can be converted into electricity more efficiently and cheaply with new photovoltaic techniques being developed by British Petroleum (BP). As well as improving the performance of silicon solar panels, its solar company has now produced prototype power modules using thin semiconductor film in a relatively inexpensive manufacturing process.

While cenventional silicon solar cells need to be several hundred microns thick, BP Solar has devised ways of electro-depositing a one to two micron film of a semiconductor known as cadmium telluride (Cd Te), said to absorb light 140 times more effectively than silicon at a 0.52 micron wavelength.

A similar technique can be used to create a film of cadmium sulphide (CdS). By depositing CdE over a CdS layer on a tin oxidecoated glass substrate and fitting a back metal contact, a compact, low-cost thin film solar cell is constructed. Initial modules are 900 square centimetres, and the company is continuing development work on unifrom film deposition over large areas. The module is divided into 35 segments which are connected in series, enabling electrical power to be derived at low current but high voltage.

BP Solar's latest high-efficiency silicon cell technology is designed to enable efficiency to be improved from the 14 per cent achieved by 'the present generation of volume-produced silicon solar cells to much nearer the theoretical maximum efficiency of converting unconcentrated sunlight to electricity. regarded as around 28 per cent.

DONKEYS FOR DRAUGHT POWER :

Sixteen families in testse fly-infested north Cokwe have this year received a total of 64 donkeys from Christian Care Relief Organisation, to use for draught power.

Christian Care started providing donkeys to the area in late 1987, when they realised that families there were using hoes and not ploughs to till their land, as most places were infested with tsetse fly and peasants could not keep cattle. More than 100 donkeys, ploughs, seeds and other inputs have since been sent to the area. Unlike cattle donkeys can stay in areas where there is tsetse fly.

FLUORIDE TOOTHPASTES HARMFUL

Should we use toothpaste with fluoride ? The question has been asked in the wake of a starting disclosure in the British medical journal, Lancet, which says that an estimated 20 million people in India are victims of flourisis. Excess intake of flouride can damage the kidney, liver and nervous system, in addition to causing abnormalities in the bones. It has been pointed out that fluoride levels in ground-water sources, in the country range from two to 39 parts per million although the recommended level is only 1 ppm.

The study by a Delhi-based physician, Dr. Bhupesh Mangla, said that already 12 States and the Union territory of Delhi were declared endemic because of the prevalance of fluorosis. According to the journal the soil in India is already rich in fluoride containing minerals and so is ground water, Fluoride is also found in some foodstuffs.

Incidentally, dentists generally, advise use of fluoride toothpastes to prevent caries. But it has been found that excess fluoride in toothpaste, apart from being injurious to the sensitive limbs of the body, may result in "mottling" and brownish discolouration. Children below six are more vulnerable, but no action has been taken so far in this regard.

Fluorosis was first detected in 1957 in Andhra and it continues to be one of the worst affected States. Lancet's finding is that fluoride toothpastes in the country have a content of the halogen derivative in levels of 1000 parts per million. The normally used raw materials in toothpastes are talc, chalk and sodium carbonates. Scientists say that fluoride is also one of the impurities. Nevertheless, the ingredients are not mixed homogenously, as a result of which a single squeeze from a tube may often yield 3000 to 4000 ppm of fluoride.

It may be recalled that fluoride toothpastes are generally products of multinationals in India which spend millions of rupees for advertisement through different media. Health workers, social welfare organisations and voluntary agencies have already cautioned against use of fluoride toothpastes through their persistent campaigns, but sale of fluoride toothpastes continues to flourish with an assurance of protection against cavities. Some of the manufacturers have gone a step further with a claim that their products are most effective in protecting tooth enamel.

However, dental infection is still the most common disease in the western countries in many of the technologically advanced nations, the prevalence of dental caries is more than 97 per cent. According to two British scientists, Dr. Grace Alderson and Dr. Tracy Black, more than eight million "working days" are lost in UK alone on account of the disease every year. In the USA, a few years ago, 24 thousand million dollars a year were spent to treat dental infections.

INDIA ADOPTS 'WASTE RECYCLING' METHOD

India is among several countries that have adopted waste-control, and pollution-curbing measures in a number of spheres to provide a cleaner and safer environment.

"Governments as well as industries all over the world have become increasingly aware of the potential value of low and nonwaste technologies (LNWT), including environmentally sound technologies, clean technologies, waste recycling, residue utilisation and recovery," says a recent report of the United Nations Environment Programme (UNEP).

In India, it is estimated the total urban population of 158 million produces nearly 18 million tonnes of annually. The expenditure on its collection and disposal works out to Rs. 300 crores.

City refuse contains plant nutrients such as nitrogen. phosphorus and potash. Compost from city refuse can be used with chemical plant nutrients to improve soil structure and weter-retaining capacity.

Under a Central scheme for solid-waste disposal, liberal grants are provided for setting up mechanical composting plants. Such plants have been installed in Bangalore, Baroda, Bombay, Calcutta, Delhi, Jaipur and Kanpur, each producing 75 to 175 tonnes of compost daily.

According to experts if all organic matter in city refuse is converted into biogas, the heat energy made available can satisfy 27 per cent of the domestic energy requirements of the population. In addition, this also eliminates pollution by solid waste

Though consumotion of paper in India is low compared to that in developed countries, a large proportion of it is recycled.

Plastics also are recycled in a number of ways. Plastic footwear is collected by hawkers and sold to small-scale unit which remake them after cleaning and grinding the plastic waste to fine size. Cheap pipes are also made out of the plastic bags and bits.

A mill, discharging about 500,000 litres of spent wash daily can generate about 15,000 cubic metres of biogas daily, providing fuel for boilers for about seven hours.

Other recycled products include disposed bottles and newspapers, silver from used photofilm and paper, lube oil, and packing material like gunny bags and cardboard boxes.

At Indian Petrochemicals, Baroda, the mere recovery of flare gas has resulted in annual savings of nearly Rs. 2 crores.

The height of the flare has been reduced to less than one metre from seven metres and fuel gas previously sent to the flare is now utilised in boilers, furnaces and other areas.

The treatment and covnersion of urban waste into energy is expected to reduce pollution in cities and help in the much needed energy generation.

A plant in Delhi is expected to generate 3.7 mw of electric power daily from 300 tonnes of waste. A Rs. sever-crore pilot plant for producing solid fuel and gas from garbage in Bombay has been approved by the Planning Commission. A private unit's effort at Patna in gen rating electricity from human waste is noteworthy.

The national Aeronautical Laboratory in Bangalore has generated power by burning sludge gas from a sewage treatment plant in life-expired aero engines.

One promising technology developed in recent years involves the production of cement from rice husk-ash.

Rice husk can also be used for manufacturing cement-like material boards for roofing and partitions, filters for rubber goods, silica cord pigments, special and insulating bricks, as well as chemicals like furfural.

Studies at the Cement Research Institute of India, New Delhi, as well as in the United States and Australia, also confirm that a substantial amount of cement can be replaced by ash, without any adverse effects on long-term strength properties. The technology's production cost is low and it is labour-intensive.

At Sangli in Maharashtra, a sugar mill will soon introduce for the first time in India, plain and laminated particle boards from bagasse, a waste from extracting.

Bagasse is rapidly emerging as an alternative to the expensive and scarcer wood.

Cooking gas which can be used as a substitute for LPG has been successfully developed from water hyacinth, a nuisance acquatic by the Central Institute of Fisheries Technology, (CIFT) in Cochin.

According to Dr. D. P. Chakraborty of CIFT, who developed the process, ten kgs of the acquatic weed can generate half a kilo of gas which will not only meet their requirements for a day's cooking for a family of five but also keep a petromax burning for a few hours.

Industrial effluents from tannery units can be used to raise fodder crops according to a study by the Tamil Nadu Agriculture University in Madurai.

Spot Light

FUTURE CYCLE

The bicycle is the answere fo free cities in the world pollution and traffic congestion, 'says a world environmental research body.

It has called upon India, China and some of the industrialised nations like the United States to set up a "bicycle advisory council" to promote cycling as an effective means of fighting pollution, urban gridlock, traffic jams and to save fuel.

The council could help decision makers ensure that all transport improvements consider the needs of cyclists. Besides, building codes and ordinances could also specify that new developmental plans should include bicycle parking, and new or rebuilt bicycle pathways for easy mobility to hikers.

More people depend on the bicycle for private transportation than any other vehicle, according to a new study by the World Watch Institute, a Washington DC based research agency. The author called the bicycle the "vehicle of the future.".

CDRT NEWS

* Prof. H. C. Srivastava, Dean R&D / Head CDRT returned after two month's stay as Visiting Professor to the Teacher's Training University, Flensburg West Germany. Prof. Srivastava, besides his academic assignment, visited leading Renewable Energy and Appropriate Technology R&D Centres and Industries. He also visited the Danish Renewable Energy Centre and finalised a 3 year's collaborative project with this Centre. Two experts from the above Centre are accepted to visit C.D.R.T. for 2 weeks; to work out the Project details. In West Germany Prof. Srivastava also finalised a 2 year's Improved Water Mill Extension Project in collaboration with German Appropriate Technology Exchange and guided the design, construction and installation of an Improved Water Mill near the Gluckberg lake situated 13 Km. from Flensburg City.

* A project on Low Cost Solar Cooker-Cum-Drier has been taken up by the CDRT, IERT, Allahabad. The first prototype has been fabricated and is under testing. The body of the prototype is made of bamboo, absorber of dull blacked painted M. S. Sheet and cover of sheet glass.

* A project on Low Cost Solar Drier has taken up by CDRT. The first prototype has been made and drying of some vegetables like tomato, bitter-gourd, has been successfully done. The drier is specially designed for the rural areas with the objective to process the fruits and vegetables available in large quantities.

* For Solar radiation data measurement Pyranometer (global diffused solar radiation) and Pyranometer with shading ring (global diffused solar radiation) have been installed and Pyrheliometer 'actinometer' (direct solar radiation) has been set up in Renewable Sources of Energy Laboratory. These instruments will be used for R&D and teaching work.

"The best way of doing a thing is to do it."

Forthcoming Events

LOW COST SANITATION :

A training course on "Low Cost Sanitation" will be held at Ahmedabad, from October 23-27, 1989. The course coordinator will be the Action for food production (AFPRO) and hosted by Safai Vidyalaya Ahmedabad. The tentative outlines for the course are : What is sanitation ? Different dimension, design consideration of pour flush latrines, various parts of sanitation concent, personal habits-domestic waste water disposal, soakage pits, cattle sheds and smokeless chulhas.

For further information contact :
Safai Vidyalaya
Harijan Ashram
Mahatma Gandhi Ashram Marg
Ahmedabad-380027
Gujarat.

TRAINING COURSE ON BIOGAS TECHNOLOGY

Action for Food Production (AFPRO) will coordinate a Training course on "Biogas Technology for Supervisors / Technicians / Promotors" at its Aligarh Project from Dec. 5-9, 1989.

The course outline are : Introduction to biogas technology, design in construction, operation & maintenance of biogas plants—Janata and Deenbandhu, Biogas transportation & utilization, Biogas & sanitation.

For further information contact :
AFPRO Aligarh Project
Aligarh
Uttar Pradesh.

TECHNOLOGICAL CHANGE AND WOMEN TOWARDS 21st CENTURY :

Common-wealth Secretariat, National Institute of Science Technology & Development Studies (NISTADS) and Council of Scientific and Industrial Research (CSIR) are jointly organising an Asian Workshop on "Technological Change and Women-Towards 21st Century" at New Delhi from "Nov. 27 to Dec. 1, 1989.

The workshop will emphasize the socio-economic impact of the new technologies including food and food products, post harvest technologies, household machinery and equipment, energy and fuel saving appliances, domestic aids including literary aids etc, and also the changes in these technologies.

Sub themes for the discussion are : (a) Policy and approaches in integrating science and technology changes into development programmes especially in relation to women (b) Technological assessment, relating to agriculture, health, nutrition, education, family planning and occupational hazards on various target groups in rural development. (C) Designing new technologies to suit women (D) The impact of information technology and other new technologies on the life and employment of women. (E) Technological changes and their impact on the socio economic cultural status of women.

The workshop is for policy makers, working scientists both in urban and rural areas, science and technology educations, teachers, writers and journalits and also for representatives of concerned international/regional agencies.

For further information contact :
Ms. Radha Chakravarthy
Scientist-Workshop Convenor
National Institute of Science,
Technology & Development Studies (CSIR)
Dr. K. S. Krishnan Road
New Delhi 110012

INDIA'S ENERGY CONSUMPTION IN THE YEAR 2000

Petroleum Conservation Research Association (PCRA) New Delhi in collaboration with Friedrich

Ebert Foundation (FES) Bonn, West Germany, is organising an International Conference on "India's Energy Consumption in the Year 2000—Towards Delinking Economic Growth and Energy Use," at New Delhi from Nov. 9-10, 1989. The conference aims to bring together leading experts from around the world to share their expertise on topics of immediate concern to the oil, gas and other energy consuming industries.

The topics to be discuss in the conference are : (a) The Indian Energy Scene ; problems and prospects, (b) The Indian Situation : This also covers the subtoipcs—1. Energy & structural changes in the economy 2. Energy planning & economic policies 3. Energy conservation : sectoral approaches 4. Non conventional energy sources 5. Rural energy problems, 6. Energy & environment 7. Non conventional energy : situation & problems (C) International experiences of some of the developed/industrialised countries and (D) Towards delinking economic growth & energy consumption.

For further information contact :
Mr. S. K. Gupta
Petroleum Conservation Research
Association (PCRA)
603, New Delhi House
27, Barakhamba Road
New Delhi-110001

WATER 1989

Asian Institute of Technology, Chulalongkorn University, Thai Environmental Engineers Association in conjuction with Communication International Associates are jointly organising an international conference on "Water 1989, at Bangkok, Thailand from 14-17 December 1989. The theme of the conference is "Water Decade and Beyond," with special emphasis on : Alternative water sources, water conservation, water pollution preservation, computer application, water and waste water treatment, small water and waste water treatment system, water reuse and recycling, industrial waste water management, hazordous waste management and water desalination.

For further information contact :
The International Secretariat
Water 1989 Conference
Communication International
Associates Pvt. Ltd.
450 Alexendra Road
10-00 Inchcape House
Singapore 0511

WATER 1989 EXHIBITION

A three-day International Exhibition on Water and Materials will be held in conjuction with the WATER 1989 conference. The theme of the exhibition is "Towards the Solution of Water and Sanitation Problems."

Equipment such as those that will be displayed in the exhibition are essential to efforts at providing safe drinking water and sanitation facilities to the populations of the world. It is specially organised to coincide with the conference and will be held at the venue and time as the latter.

For further information contact :
Water 1989 Exhibition
Communication International
Associates Pvt. Ltd.
450 Alexendra Road
10-00, Inchcape
Singapore 0511

SMALL SCALE IRRIGATION

Continuing Education Centre, Asian Institute of Technology, Bangkok Thailand, will be organize a training programme on "Planning and Design of Small Scale Irrigation Projects," from 5th Feb. to 30th March 1990, and 4th Feb. to 29th March 1991 (8 weeks). The training programme is for Planning and Design Engineers.

For further information contact :
Dr. N. C. Austriaco
Director,
Continuing Education Centre
Asian Institute of Technology
G. P. O. Box 2754
Bangkok 10501
Thailand.

AGROFORESTRY SYSTEMS

A Conference on "Agroforestry Systems and Multipurpose Trees" in Chiang Mai, Thailand, will be held in October 1990, organised by International Tree Crops Institute.

For further information contact :
Mr. Henry Ebenshade
President
International Tree Crops Institute
P. O. Box 283
Caulfield South
Victoria 3162
Australia

QUEST FOR TECHNOLOGY

National Foundation of Indian Engineers (NAFEN) in collaboration with a number of academic societies and organisations is going to organise the 3rd International Congress & Exhibition, "QTECH 1989," at New Delhi from Nov. 23-24, 1989. The main theme of the congress is "Appropriate Technologies for Rural India and Third World."

For further information contact :
Mr. P. K. Gupta
Hony. General Secretary
National Foundation of Indian Engineers
11/6 B, Pusa Road
New Delhi.

INTEGRATED RURAL ENERGY SYSTEM

A National course on "Integrated Rural Energy Systems" (IRES) will be organised by Consortium on Rural Technology at Delhi from 8th December 1989 for three/four weeks duration.

The course aims at comprehensive inputs of knowledge and information on Decentralised Energy Technology, their State of Art and Technical & Socio-economic viability, Energy Planning, Policy Issues in context of overall rural development at various levels, Formulation of Integrated Energy Projects and their effective Implementation and Management. They will also provide know how and skills with regards to systematic analysis and decision processes involved in planning, implementation and evaluation of rural energy projects.

The course is for supervisors, managers; Investigators and also for field workers.

For further information contact :
Consortium on Rural Technology
D-320, Laxmi Nagar
Post Box No 9236
Delhi-110092.

News and Notes on Books and Publication

ENERGY DIGEST

This is a publication of TATA Energy Research Institute. It attempt to cover most recent foreign literature on energy that is relevant to the developing countries. Both conventional and non-conventional sources of energy are included, through the entire cycle from exploration to utilization and conservation.

Energy Digest is published six times a year. Each issue of ED comprises about 100 abstracts and 4-5 extended summaries and digests. It prepared after regular scanning of primary source materials, primary journal and other sources such as conference proceedings, technical reports, books etc. Original documents for all the summaries, digest, and abstracts published in Energy Digest are availble in their library.

Photocopies of the documents or selected references may be requested from :

TATA Energy Research Institute
Documentation and Information Centre
7, Jor Bagh
New Delhi-110 003

RESIDENTIAL AND NON-RESIDENTIAL DRINKING WATER INSTALLATIONS AND DRAINAGE REQUIREMENTS IN NEPAL

The proper installation of water supply and drainage disposal systems provides a convenient service of great importance for public health. Unfortunately bad plumbing is the bane of many countries.

In Nepal, good training facilities are now available in the Sanitary Section of the Mechanical Training Centre (MTC). Lessons in classrooms and workshops are based on information gained through many years of practical experience. This experience has been compiled into book form for use, both in Nepal and overseas.

This book is devided into three parts. The first section deals with "Drinking Water Installation," both direct mains connection and distribution from water tanks. The second section much expanded-explains "Drainage Requirements", including the modern 'stack' system and the updated version of divided drainage/ of soil and waste waters. The third section, "Drawings/Design", consists of detail of individual apparatus, tables of connecting and disposal values, ISO-Norm symbols, etc. There are many drawings illustrating the text which has been written in precise but simple language. In this edition more than one solution is given for certain problems because some norms differ from country to country. In all cases, however, care was taken to use standard terminology. The book is intended to be used as manual and reference work by practising sanitary engineers.

"Residential and Non-Residental Drinking Water Installations and Drainage Requirements in Nepal" by Andreas Bachmann & Heing Waldgogel, Published by Mechanical Training Centre, Balajee, Kathmandu, Nepal, pp. 180, 1988, SFr. 20.00.

MANAGING SELF HELP SUPPORT-PART-I :

This book aims to make management with the inclusion of monitoring-reliable and effective. It examines the possibilities of appropriate management in self help support based on several years of practical experiences in the field.

The book is divided in five parts. After introduction the second chapter deals with guide lines for self help support and delineate some basic concepts. The third chapter highlights at procedural issues by discussing the main steps of self help support from project initiation to follow up.

In the fourth part a number of management tools are introduced which have proved their practicability and usefulness. They step us performance without loosing operational reliability.

The last and fifth chapter deals with the appropriate size for a self help support programme. This gives a wider platform and matters for possibilities of discussion as support programme. The book is supported by a useful annex based on practical example of author in Taugauia.

"Managing Self Help Support Part I : Concept and Manual Tools", by Thomas Kuby Published by German Appropriate Technology Exchange, West Germany, pp. 89.

DEVINSA ABSTRACTS (BI-ANNUAL)

Devinsa abstracts is being published by The Development Information Network for South Asia (DEVINSA). The coordinating centre provides details on socio economic development in the six south Asian countries represented in the CSCD-Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka. The subject scope of the abstracting service covers social and economic development defined in broad terms. It highlights the unpublished literature mainly. The main focus is on documents such as conference reports, reports to governments and other development agencies, published and unpublished articles, thesis, dissertations, research reports, working papers and technical reports. Relevant documents published locally and elsewhere are also included.

DEVINSA Abstracts is bi-annual publication. Each record contains a full citations followed by primary authors and subject descriptors are provided. It includes additional information in the forms of notes and an abstract.

The abstract provides timely information on current development activity in South Asia.

'DEVINSA Abstracts' (Bi-annual), Published by Marga Institute, Srilanka, Single Copy US$ 35.00 Annual subscription US$55.00.

LITTLE SCIENCE

This is a beautiful little book. Exercises on very interesting and innovative ideas. Though some of our readers may have seen these articles in Science Age. The book advocates for a human way of teaching with a trust in the children's abilities and natural resilience. In other words this book is an approach to become a catalyst. It gives a way to tread on and start a naturally creative curiosity and excitement in children, to uncover their latent talent and potentiality.

The book is aimed at Educators and children both but its a milestone to science popularisation. It raises a question mark not only against the teaching style and contents but education also. The book list innovative experiments for learning science. These experiments use cheap and easily available materials.

The author of this book is a well known authority on science popularisation through easy and cheap experiments for children. His another creation, a booklet on sience entitled 'Khel Khel Me (Hindi) is worthy to be mentioned here.

The book is recommendable to all who are involved in Science Popularisation, Education and children. CAPART'S resource on such book is quite appreciable.

"Little Science" by Arvind Gupta. Pub. by Eklavya. Bhopal.

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Publications List, 1989.

1. Rural Technology : Report of National Seminar, 1981, 20 papers on Rural/Appropriate Technology,

   English pp 268 Rs. 200/-

2. Renewable Sources of Energy : Proceedings of Short Term in Service Training Programme, 1983, 20 papers on Solar Cookers, Smokeless Cookstoves, Micro Hydro Power, Wind Energy, Biomass and Biogas etc.

   English pp 250 Rs. 200/-

3. Selection of Windmill and Agricultural Pumpsets : Course manual of Training Programme for Senior Officers of NABARD, 1984, 3 papers on Water Pumping Windmills, Special feature : Paper on agronomic aspects of Windmill Irrigation.

   English pp 39 Rs. 30/-

4. Course Synopsis of ISTE : Summer School on Renewable Sources of Energy, 1984, 12 Papers on Biomass, Biogas, Wind Energy, Solar Energy and Micro Hydel Sets etc. and 4 project reports on Solar Water Heater, Solar Cooker and Biogas plant.

   English pp 165 Rs. 150/-

5. Papers and proceedings of National Workshop on Energy from Agricultural Residues, 1985 : Back ground paper, recommendations, keynote & valedictory address and 23 papers on the topic.

   English pp 208 Rs. 200/-

6. Papers and proceedings of National Workshop on Decentralised Energy Planning for Rural Development : recommendations, keynote & valedictory address and 12 papers on the topic.

   English pp 200 Rs. 200/-

7. Course synopsis of ISTE : Manual of Training Programme for Junior Engineers of Rajya Krishi Utpadan Mandi Parishad, U.P, 1987, 17 papers on Biogas, Agricultural Implements, Wind Mill, Agriculture marketing, Water lifting devices etc.

   English pp 235 Rs. 225/-

8. Course synopsis of ISTE : Manual of Training Programme on Renewable Sources of Energy for Porject Officers of Non-Conventional Energy Development Agency, Government of Uttar Pradesh, 1987, 13 papers on Biogas, Biomass, Solar energy, Cookstove, Human & Draught Animal Power, Aero-Generator, etc.

   English pp 196 Rs. 200/-

9. A case study on Smokeless Cookstove.

   English pp 32 Rs. 25/-

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Aims & Scope :

Rural Technology Journal is published by Information Services Division, Centre for Development of Rural Technology, Institute of Engineering & Rural Technology, Allahabad (India). The purpose of the Journal is to provide a forum for exchange of views, information and create awareness in the field of Rural Technology, it's development and transfer to the rural areas, technological products and processes, methodologies and approaches etc. Effort is being made to ensure that this Journal become relevant not only for this country but to all those nations, groups and individuals, in any part of the Globe who have concern to contribute towards the welfare of the under privileged rural communites. The Journal is divided into following main sections :

1. Portfolio — (Articles/Papers)
2. Tool Box — (Information on Rural Technology/Processes)
3. Spot Light — (News and Views)
4. Futurama — (Forthcoming Events : Training Programmes, Seminars, Symposium Workshops etc.)
5. Book Bag — (News on Books and Publications).
6. Workshop — (Technical Queries)

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Papers/articles information packages, technical queries and related materials are cordially solicited. Manuscripts should be sent to :

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1. The complete manuscript should be written in English and the desired order contents of Title, Abstract, List of symbols, Main Text, Acknowledgement, Reference and Appendices. The Standard Inter-national System of Units (SI) should be used.
2. The manuscript should be typed on one side of the paper only (preferably 8"×11" bond paper) with double spacing between lines and 1" margin on the left.
3. Two copies of the manuscript and illustrations (one set original) should be sent to the Editor.
4. The title should be brief (maximum of 150 characters including blank in between words or other non-alph-abetical characters) and followed by the author's name, affiliation and address.
5. Internationally accepted standard symbols should be used. In the list of symbols Roman letters should precede lower case.
6. Grahps, charts, drawing sketches and diagrams should be black and white prints on glossy paper and preferably 3"×7" size.
7. Illustrations should be numbered consecutively, given proper legends and should be attached at the end of the manuscript.

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