EFFECTIVE AGRICULTURAL WASTE MANAGEMENT

PROCEEDINGS

OF THE

30TH ANNUAL CONVENTION

OF

INDIAN AGRICULTURAL UNIVERSITIES ASSOCIATION

HELD ON

DECEMBER 28-29, 2005

S.D. AGRICULTURAL UNIVERSITY

SARDARKRUSHINAGAR-385 506

(GUJARAT)

Sponsor

INDIAN AGRICULTURAL UNIVERSITIES ASSOCIATION

NEW DELHI

Organizer

S.D. AGRICULTURAL UNIVERSITY

SARDARKRUSHINAGAR-385 506

(GUJARAT)

Messages

सत्यमेव जयते

Raj Bhavan
Gandhinagar-382 020.

Nawal Kishore Sharma
Governor of Gujarat

Message

I am pleased to know that Sardarkrushinagar Dantiwada Agricultural University has decided to organize 30th Annual Convention of Indian Agricultural Universities' Association (IAUA) on December 27 -28, 2005 at Sardarkrushinagar.

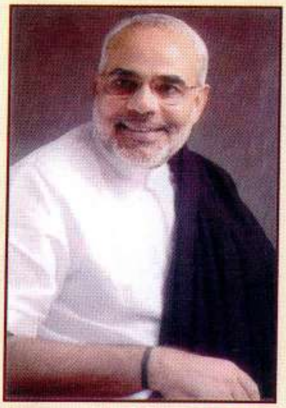
"Effective Agriculture Waste Management" an aptly chosen theme of the convention would go a long way to solve waste management problem and thereby to increase crop manifold. It would also help reaping wealth from waste and generating additional employment opportunities, I hope.

I wish the 30th Annual Convention of Indian Agricultural Universities' Association all success.

Gandhinagar.
December 12, 2005

Nawal Kishore Sharma

(Nawal Kishore Sharma)



Narendrabhai Modi

सत्यमेव जयते

Chief Minister,
Gujarat State,
'Sardar Bhavan' Sachivalaya,
Gandhinagar-382 010.

Message

I am delighted to know that Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar is Organising the 30^{th} Annual Convention of the Vice-Chancellor's of the Indian Agricultural Universities Association on December 27-28, 2005. The theme of the convention is "Effective Agriculture Waste Management".

The convention envisages to address various issues related to effective utilization of agricultural waste. In addition, the problems faced by agricultural Universities will also be discussed. I am confident that the key issues confronting agricultural research and development will receive due attention during the deliberations.

I hope the galaxy of participants at this important event will come out with important conclusion and recommendations keeping in view future needs of agricultural development.

I wish convention grand success.

Gandhinagar
December 12, 2005

(Narendra Modi)

Bhupendrasinh Chudasama

सत्यमेव जयते

Minister, Agriculture, Animal
Husbandry, Co-operation,
Fisheries & Panchayat,
1/7, Sardar Bhavan,
Gandhinagar.

Message

I am extremely happy to learn that SDAU, Sardarkrushinagar is organizing 30th Annual Convention of the Vice-chancellor's of the Indian Agricultural Universities Assoiciation on December 27-28, 2005 with the theme "Effective Agricultural Waste Management". There are several promising avenues like biogas and power generation, production of molasses, animal feeds and organic manures etc. which needs detailed discussion for their efficient management.

The S.D. Agricultural University has progressed well during its short period of coming into existence. The present convention would provide an opportunity to the University to further strengthen on its research agenda and academic activities.

I extend my good wishes to the organizers and participants for the success of this event.

Gandhinagar
December 12, 2005

(Bhupendrasinh Chudasama)

डा. मंगला राय
सचिव एवं महानिदेशक
DR. MANGALA RAI
SECRETARY & DIRECTOR-GENERAL

सत्यमेव जयते

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN,
NEW DELHI 110 001
TEL. : 23382629, FAX : 91-11-23387293
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Message

It is pleasure to know that the 30th Annual Convention of the Vice-Chancellor's of Indian Agricultural Universities is to be held during December 27-28, 2005 at SDAU, Sardarkrushinagar (Gujarat).

In a country like India about 142 mha. under cultivation, a large number of livestock, poultry and a vast quantity of fish production, it is abvious that large volume of agricultural waste is also generated with main produce, that often creates problems of disposal and environmental pollution. We need to develop technologies to convert the waste into wealth in form of useful by products. I am happy to learn that effective utilization of agricultural waste is being deliberated in the Convention besides regular business related to Agricultural Universities.

I wish the Convention a grand success.

December 26, 2005

(Mangala Rai)

Vice-Chancellors' conference discussed new dimensions in "Effective Agricultural Waste Management". Sitting on the Dias (from left to right are) : Dr. R.P.Singh, Secretary, IAUA ; Dr. S.S. Magar, Vice-Chancellor, BSKKV, Dapoli and Vice-President, IAUA ; Dr. K.C. Khandelwal, Advisor, Ministery of Non-Conventional Energy ; Dr. S.B.S. Tikka, Director of Research, SDAU, Sardarkrushinagar ; Sh. Bhupendrasinhji Chudasama, Hon'ble Minister for Agriculture, Gujarat State ; Dr. S.N. Puri, Vice-Chancellor, CAU, Imphal and President, IAUA ; Dr. M.P. Yadav, Director, IVRI, Izatnagar and Secretary-Treasurer, IAUA and Dr. H.N. Kher, Registrar, SDAU.

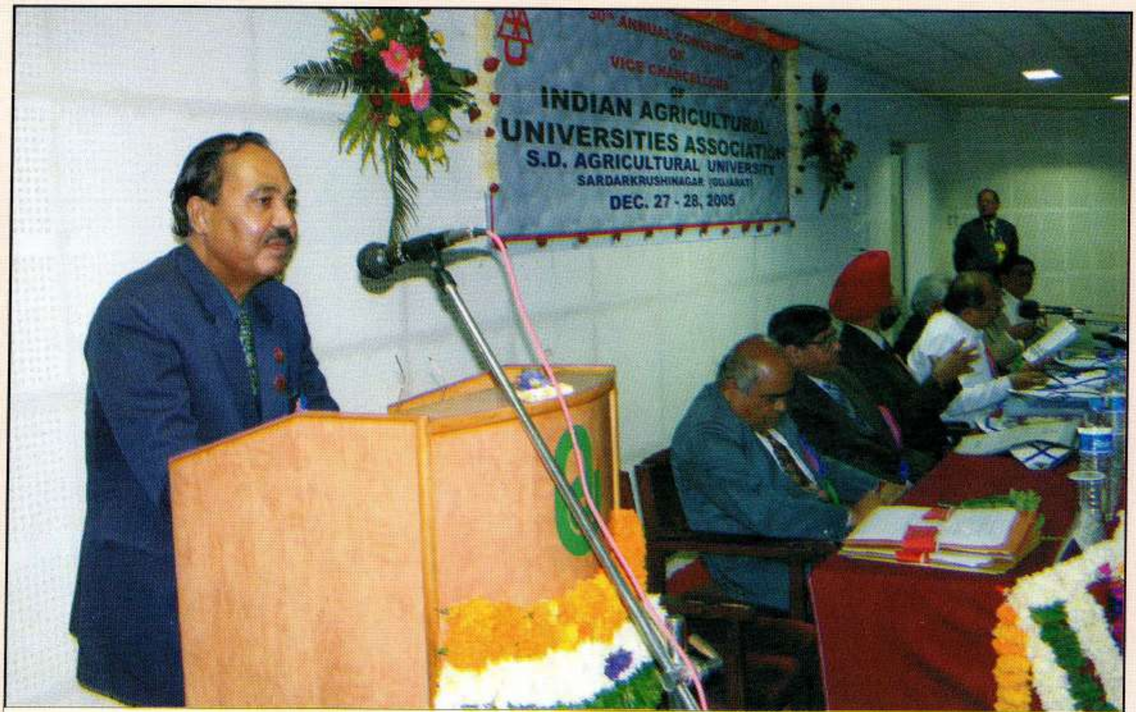
Hon'ble Minister for Agricultural Sh. Bhupendrasinhji Chudasama Inaugurating the IAUA Convention.

Dr. S.B.S. Tikka, Director of Research, SDAU, Sardarkrushinagar Delivering Welcome Address.

Dr. K.C. Khandelwal, Advisor, Ministery of Non-conventional Energy Delivering Key-note Address

Hon'ble Minister for Agriculture and Co-operation Sh. Bhupendrasinhji Chudasama
Delivering the Inaugural Address.

Dr. S.N. Puri, Vice-chancellor, CAU, Imphal and President, IAUA, Delivering the Presidential Address.



Dr. R.P.Singh, Secretary, IAUA, Presenting the Activities of IAUA.

Meeting of the Executive Committee of IAUA in Progress

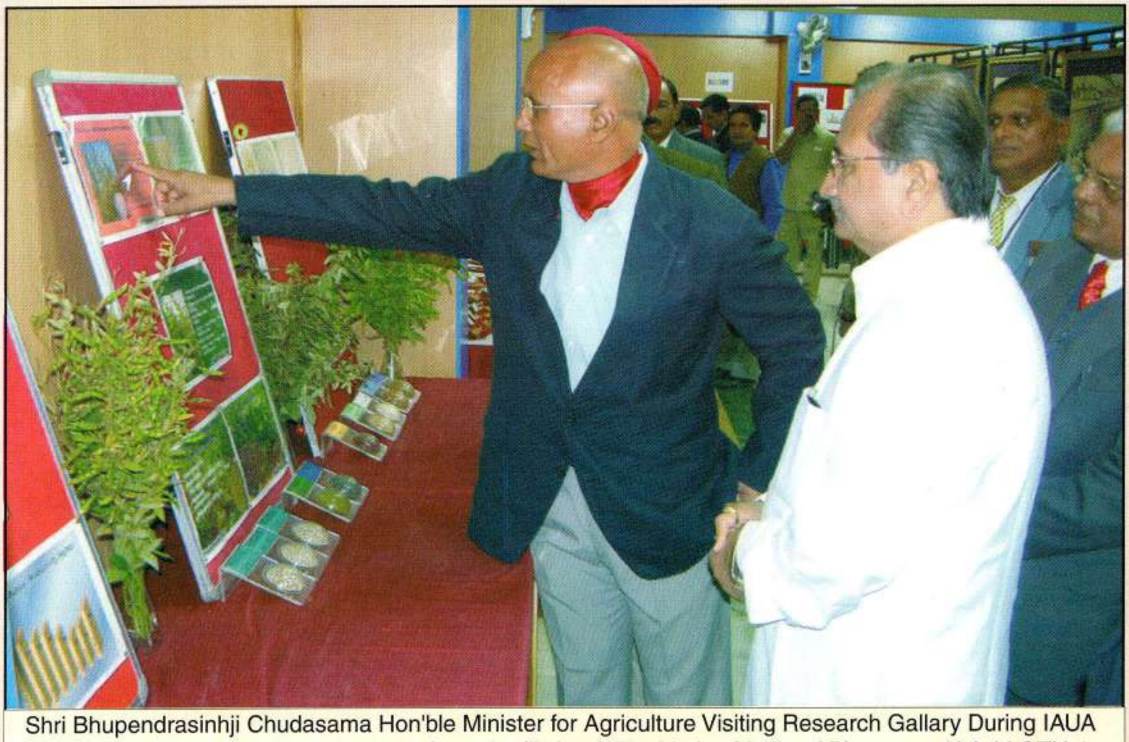
Participating Dignitaries at the Inaugural Functions of IAUA.

Participating Dignitaries at the Inaugural Functions of IAUA.

Dr. S.B.S. Tikka, Director of Research, SDAU, Sardarkrushinagar Presenting Memento to Dr. S.N. Puri, Vice-Chancellor, CAU, Imphal and President, IAUA

Dr. S.B.S. Tikka, Director of Research, SDAU, Sardarkrushinagar Presenting Memento to Dr. M.P.Yadav, Director, IVRI, Izatnagar and Secretary-Treasurer, IAUA

Dr. S.S. Baghel, Vice-Chancellor,AAU, Assam (center), Dr. S.S. Magar, Vice-Chancellor, BSKKV, Dapoli (right) and Dr. S. Acharya, Research Scientist, Pulses (left) during technical session-I



Shri Bhupendrasinhji Chudasama Hon'ble Minister for Agriculture Visiting Research Gallary During IAUA Convention. Dr. S. Acharya, Research Scientist (Pulses) Elucidating Merits of Pigeonpea Hybrid GTH-1

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Welcome Address

S.B.S. Tikka

Director of Research, S.D. Agricultural University, Sardarkrushinagar

Hon'ble Minister for Agriculture & Cooperation, Gujarat State Shri. Bhupendrasinhji Chudasama, President of IAUA, Dr. S.N. Puri, Vice-President of IAUA, Dr. S.S. Magar, Treasurer and Secretary, Dr. M.P. Yadav, Advisor, Non-conventional Energy Sources, Government of India, Dr. K.C. Khandelwalji, Secretary IAUA, Dr. R.P. Singh and Registar SDAU Dr. H. N. Kher, distinguished galaxy of Vice-Chancellors, Deans, Directors, Scientists from Indian Agricultural Universities, fellow scientists, persons from press and electronic media, ladies and gentlemen.

We feel privileged to host this most important 30th Convention of Vice-Chancellors of Indian Agricultural Universities being held at Sardarkrushinagar. Infact, our Hon'ble Chief Minister, Shri Narendrabhai Modi has been giving top priorities to activities concerning agricultural research and development related to farming community and rural development. He was too keen to organize this conference here in this part of Gujarat.

Hon'ble Minister for Agriculture, Shri Bhupendrasinhji Chudasama has become a symbol of agricultural development in the country during the last couple of years and was very kind in accepting our request for inaugurating this function. Sir, we are graced with your presence and believe that your persuasive leadership will play a spurring effect during the deliberations of this mega event. Sir, it would not be out of place to mention your pivotal leadership in organizing events for the benefits of the farmers. The nation has recognized your leadership in organizing the first ever *Krishi Mahotsava* in eighteen thousand odd villages of Gujarat wherein the farmers were made abreast of the latest agricultural technologies right at the doorsteps of the end users. We heartily welcome you and feel encouraged by your presence.

I welcome functionaries of IAUA, Dr. S.N. Puri, President, Dr. S.S. Magar, Vice-President, Dr. M.P. Yadav, Treasurer-secretary and Dr. R.P. Singh, Secretary to mention a few among them. Dr. K.C. Khandelwal, Advisor, Non Conventional Energy Sources deserves special welcome on account of his accepting the responsibility of delivering keynote address despite a very short period.

We feel especially privileged to welcome the distinguished galaxy of the Vice-Chancellors of different Agricultural Universities who made it convenient to honour this university with their graceful presence despite awkward weather that made their journey inconvenient. I also welcome the Deans, Directors, other officers and executives of different universities and institutions for gracing this occasion.

I am also taking this opportunity to welcome persons from press and electronic media and believe that they will give a good coverage to this first ever historical event being organized in Gujarat.

Finally, I welcome all the member delegates with the hope that the deliberations during the convention would be very fruitful not only in managing the agricultural waste but equally informative and helpful for ameliorating the financial status of the farming community.

JAI HIND

Key-note Address

Effective Agricultural Waste Management

Dr. K. C. Khandelwal

Adviser, Ministry of Non-conventional Energy Sources, Government of India, New Delhi.

Hon'ble Minister for Agriculture Shri Bhupendra Singhji Chudasama; Dr. S. N. Puri, President, IAUA and Vice Chancellor, Central Agricultural University, Imphal; Dr. S.B.S. Tikka, Director of Research and Dean PG Studies ; friends on the dias, members of the press, distinguished Vice-Chancellors, delegates, ladies and gentlemen.

It is indeed a great pleasure for me to participate in this 30th Annual Convention of the Indian Agricultural Universities Association. I am grateful to Dr. B. S. Chundawat, Vice-Chancellor, Sardarkrushinagar Dantiwada Agricultural University for inviting me to deliver a Key-note address on an important topic 'Effective Agricultural Waste Management'. I pray to Almighty for his fast recovery.

As you are aware, the year 2005, which is coming to close, has been celebrated as the International Year of Physics. The great physicist Einstein pointed out that matter is nothing but energy waiting to happen. Energy lies all around us but turning matter into energy effectively is the hard task.

The so-called 'agricultural wastes', such as wood, crop residues and cattle dung, are actually low-value produce in the context of our country because they are the main source of animal- feed, mulch and manure, besides cooking fuel. At present these biomass resources are fulfilling about 36 per cent of primary energy consumption, mainly to meet cooking and heating energy requirements in our rural areas. However, biomass is burnt in a most inefficient manner in traditional cook-stoves, thereby not only energy is wasted but smoke in kitchens is also causing health problems, such as acute respiratory diseases mostly among infants and women. On the other hand, in agriculturally prosperous areas like Punjab, the common practice of on-farm burning crop residues, such as rice straw, to clear land for sowing of next crops is causing air-pollution and it needs to be discouraged. Moreover, increased consumption of biomasss fuels lead to agricultural and ecological imbalances and can not be sustained for long. While the right place for crop residues and cattle dung is their recycling back to agricultural fields, excess quantity could be effectively used for both heat and electricity. An important argument for using biomass for energy purposes is that it does not contribute to increasing CO_2 content in the atmosphere, thereby not aggravating the greenhouse effect.

In the present paper, an attempt is made to highlight the use of crop residues, agro-processing industrial waste and cattle dung for heat and electricity generation. Resource assessment, biomass handling machines, combustion, gasification and fermentation technologies and a concept of bio-refinery are discussed. This paper does not deal with the subject of energy plantation and production of biodiesel, which have also gained importance in recent years.

Resource Assessment

National Productivity Council, New Delhi estimated production of about 439 million tonnes of crop residues in 1985-86 and National Dairy Research Institute, Karnal estimated production of about 960 million tonnes of wet cattle dung in the year 1975. National Council of Applied Economic Research, New Delhi conducted a Domestic Fuel Survey in 1978-79 and reported that about one-half to one-third of crop residues and cattle dung produced in the country were burnt for cooking and heating energy purposes. As a source of cooking fuel, cattle dung is used more in northern states, whereas crop residues are predominant in southern states. Wood is the main cooking fuel in eastern and north-eastern states.

Estimates worked out by Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar, Gujarat in 2004 indicated that at least 70 million tonnes of crop residues would be available annually for power generation in the country.

Under a project entitled 'Biomass Resource Atlas of India', both Indian Institute of Science and Regional Remote Sensing Service Centre, Bangalore have already prepared a stand alone computer package providing information on availability of excess crop residues at the taluka level in the country and are expected to prepare a web-enabled atlas by March 2007.

Biomass handling

Crop residues are bulky in nature and require machines suitable for their handling and transportation and also special storage facilities. Piston presses for briquetting of loose biomass are manufactured in the country, but they are not trouble-free. Without developing heavy machines, such as mowers, cutters, roto-cut balers, stackers, racks, etc., improving designs of briquetting/pelletting machines and designing proper storage facilities, it would not be easy to attempt the use of crop residues for large scale electricity generation. In this area, we should draw benefit from the experiences available in European countries and the USA.

Technology

Combustion, co-generation and gasification processes are used for thermal conversion of crop residues and agro-industrial wastes into heat and electricity. Another area of interest is fermentation of lignocellulosic materials into either biogas or ethanol. Standard configuration of high pressure boilers with steam turbines is available in the market for 3 MWe to 15 MWe power and cogeneration units. Technology for biomass gasifiers with producer gas engines or gas engines in the range of 5 kW to 300 kWe has also been developed indigenously.

India is one of the leading countries in developing and promoting a simple-to-construct and easy-to-operate biogas plants based on cattle dung. Designs of floating gas holder and fixed dome and die-off of pathogens in biogas digesters were presented. Some of the recent R&D achievements in the fields of biogas are mentioned below:

- At the Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar, Gujarat a pilot process for thermophilic biomethanation of rice straw has been developed and they are planning to set up a full scale plant.
- A biogas-fired chick brooder has been designed at Poultry Experimental Station, Livestock Research Institute, ANG Ranga Agriculture University, Rajendranagar, Andhra Pradesh.
- Indian Institute of Technology, Delhi has developed a biogas cleaning and purification system for using biogas as transport fuel.
- Field trials on the use of biogas manure, as a source of humus and plant nutrients, including trace elements, carried out at various locations under the aegis of Indian Council of Agricultural Research showed that in general about 50 per cent of the recommended N-fertilizer dose could be replaced by manure without significantly affecting grain yield of wheat, paddy, maize, sorghum, groundnut, soybean, etc.

Some European countries have developed techniques for upgrading biogas to the level of natural gas.

On fermentation of lignocellulose into ethanol, which is receiving priority in the USA, not many institutions are working in India.

Achievements

The Ministry of Non-conventional Energy Sources has been implementing many schemes for biomass power/cogeneration, gasification and biogas production. Financial and fiscal incentives are given through state nodal agencies. The financial arm of the Ministry namely Indian Renewable Energy Development Agency (IREDA) is providing loan facility to manufacturing units and for projects. So far projects of a cumulative total installed capacity of 491 MW of bagasse co-generation, 376.53 MW biomass combustion and one MW biomass gasification have been set up in the country, against an estimated potential of 5,000 MW cogeneration based on bagasse and 16,000 MW of biomass power based on crop residues and wood waste.

Two case studies of biomass power projects in Andhra Pradesh and a 500 kW biomasss gasifier project at Chhotomollakhali Island, Sundarban, West Bengal were presented.

A cumulative total of 3.5 million household biogas units have been installed. In Gujarat, about 3.78 lakh biogas plants have been installed so far and it stands at third position, after Andhra Pradesh and Karnataka, which have 3.92 lakh and 3.90 lakh plants respectively.

Bio-refinery

A bio-refinery is a processing plant where biomass feedstocks are converted and extracted into a variety of valuable products and fuels similar to the petrochemical refinery. R&D efforts are focused towards developing bio-refinery in the USA. Besides lignocellulosic materials, green grass, lucerne, berseem, or immature raw cereal and even whole crops are considered as feedstocks.

Future R&D Areas

Agricultural universities may like to consider taking up R&D in some of the important areas and demonstrations for effectively managing low-value produce of agriculture enumerated below:

- Determining reliable and area-specific availability of biomass for power generation;
- Determining quantities of various kinds of biomass for recycling to sustain soil fertility;
- Developing heavy duty machines for collecting, drying, densification and transportation of loose biomass;
- Use of biomass ash as a value added product;
- Upgrading biogas to serve as a fuel for automobiles, tractors and engines
- Fermentation of crop residues for production of ethanol; and
- Setting up a pilot bio-refinery facility for testing of different feedstocks and developing commercial technologies for production of liquid and gaseous fuels and chemicals.

At the end, I thank and wish you all a happy and prosperous New Year 2006.

Inaugural Address

Bhupendrasingh Chudasama

Minister, Agriculture, Animal Husbandry, Co-operation,Fisheries and Panchayat, Government of Gujarat, Gandhinagar, Gujarat.

Dr. Puri, President of IAUA, Dr. Singh, Secretary IAUA, Dr. Khandelwal, Dr. Tikka, delegates ladies and gentleman. At the outset, I appreciate the gesture of the IAUA for holding this Annual Convention at Sardarkrushinagar.

I am happy to be with you in this inaugural function of 30^{th} annual convention of Indian Agricultural Universities Association. In fact our beloved Chief-minister Shri. Narendrabhai Modi immediately accorded his consent and was very much keen to see that this convention is held in Gujarat. I congratulate Dr. Chundawat for taking up this herculian responsibility of convening the Vice-Chancellors' conference at Sardarkrushinagar. Infact this is my third visit to this place during the last four months. All of you are aware of the fact that Gujarat has made commendable progress in Agriculture. We anticipated (GDP Agri) Rs. 9000 crores by the year 2005. The farmers, scientists and extension workers had achieved Rs. 21000 crores which is over two times of the estimated target. This year the GDPA is expected to cross Rs. 30000 crores. The *Sujalam Suphlam* was another noteworthy accomplishment. Considering the expertise of Gujarat in agriculture, the central government sought the guidance of Shri. Narendrabhai making him the Chairman of Soil Resource Management in the Planning Commission for the next plan period (2007-2012). We need cooperation of learned people like you to help us with pragmatic suggestions and solutions to come out triumphant. Politics apart, potable water availability in the nick and corner of our *Mahabharat* should be dream worth nurtured by all of us in a concerted way. The recent meet of WTO held at Hongkong made resolution in favour all developing nations. Our farmers would enjoy subsidized power and fertilizer supply. The agricultural produce movement would be checked to protect the farmers of developing nations. The wealthy west world put an end in a phased manner to the export subsidies given to their farmers. Under this scenario it is pertinent to state that we upscale our technologies to prevent post harvest losses, produce value added commodities and conserve and judiciously utilize the waste. The topic selected for deliberation in this convention is more relevant to the present agricultural situations in the country. A word waste is considered as "a matter in the wrong place". In general the waste may be the damaged, defective or superfluous material produced from agricultural manufacturing processes, discarded material from agriculture and forestry, refuge available from the human and animal habitations which are without being utilized or under utilized on the site.

The agricultural waste primarily originates from plants and animals. Presently most of this waste is either underutilized or unutilized. If we talk of Gujarat, cotton is cultivated in large acreage. The cotton stalks have no economic value. Likewise the stalks of castor, mustard, sesamum, pigeonpea, fennel and banana stems, potato haulms etc have also no economic utilization. Estimates of agricultural waste availability in India suggest that the annual average quantity for crop waste is 493 million tones and that of animal waste is 650 million tones. However, only 39 % of the crop waste is utilized for the purpose of recycling in India.

Improper and inadequate collection and disposal of agricultural waste poses the problem of human health and is an obvious cause of environmental degradation in developing countries. Mix fruit and vegetables wastes dumped indiscriminately leads to hygienic hazards by attracting rodents and disease carrying vectors. It is also responsible for pollution of air, water and soil through lechates. Thus, if such wastes are not handled properly and utilized effectively they can seriously affect the biology of the earth.

Hence, we have to think of for these issues. You all being experts in this subject have to find out the solutions. As a lay man, I would like to state that the waste management should be in a manner that it is in accordance to the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. As I understand the economic value of agricultural waste may be considered in the utility of energy generation, raw material for industries and above all manurial value.

Today, the main source of energy in the villages is fire wood, cattle dung cakes and other agricultural wastes. The villagers are using these sources for their domestic requirements. With increasing population, the energy consumption is increasing in the rural and urban areas. Utilization of agricultural waste for production of biogas and other energy value products is the need of the day. We have to think for the other wastes like night soil, poultry dropping, pig manure, dung and urine of goat, sheep and camel for production of biogas and manure by improving our traditional systems.

The another area wherein the agricultural waste can best be managed for raw materials is in various industries. The by products as we talk now include straw, husk, stalks, leaves, twigs, bran, sugarcane baggasse, fruits, flowers and vegetables processing waste, agro based industries waste as well as the by products of dead bodies of animals. The scope for such by products is in paper and pulp industries, animal feed and concentrates. The carcass and slaughter house wastes can also be processed to yield certain economic products. The technology advancement for utilization of by products of stray dead animals also need attention.

The Government of Gujarat this year celebrated *Krishi mahotsava* which is the largest extension programme of the world. The motto behind the programme was to apprise the farmers about the latest agricultural technologies to double the income of the farmers within next five years and bringing second green revolution through water management (*Jal Kranti*). During the *Mahotsav* the administration has come at the doorsteps of the farmers. At the village level various activities viz., explaining the farmers village crop production plan, transfer of technologies, distribution of agricultural/horticultural/animal husbandry kits each to five poorest of the poor farmers. Guidance to the farmer related to farming problems, distributing soil health card and *Kisan* credit card, collecting soil samples, distributing farm literature, sanctioning bank loans for purchasing agricultural implement, brief sets and sprinkler sets etc. were carried out.

The time has come now to think very seriously of the soil health, as it is being deteriorated due to improper and indiscriminate use of agricultural chemical and fertilizers. On the other side the energy crises has increased the cost of fertilizers. The gap between the requirement and availability of nutrients is widening day by day. Today it is about 10 million tones for NPK, which may be obtained through recycling of nutrients by all alternate means. In our country we have ample availability of organic agricultural wastes. Therefore, our emphasis should be on manurial value of such wastes. Government of Gujarat has given top priority to soil health card programme and also to organic farming in the crops wherever possible. With this programme the farmers will be able to know the fertility status of their fields and accordingly plan to supply nutrients in an integrated manner so that the problems of pollution and residues in food products is minimized.

Finally, I congratulate the organizers and sincerely appreciate the deligates for venturing their visit to this place. I hope your stay in Gujarat would be comfortable and enjoyable. I am confident that given the presence of the learned dignitaries of the country among the deligates, the deliberations would bring forth meaningful recommendations in conserving and utilizing the agricultural waste in the best way. I am sure with the imminent recommendations of this convention nothing would be deemed waste in future since the nature never support waste.

Jai Hind, Vande Matram

[illegible] supported [illegible] carried out.

The [illegible] due to [illegible] use of agricultural chemicals and fertilizers. On the other side the [illegible] increased the use of fertilizer. [illegible] and [illegible] through recycling of [illegible] by alternative means. [illegible] we [illegible] adoption of organic agricultural systems. Therefore, [illegible] on integrated [illegible]. Government of Gujarat has given [illegible] soil health card programme and also [illegible] farming [illegible]. From this programme, the farmers will be able to know the fertility status of their fields and accordingly plan to supply nutrients in an integrated manner, so that the problems of pollution and residues in food products are minimized.

Finally, I congratulate the organizers and sincerely appreciate the delegates for extending their [illegible] I hope [illegible] conference [illegible]

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Vote of Thanks

H. N. Kher

Registar, S. D. Agricultural University, Sardarkrushinagar

It is my privilege to propose a vote of thanks to this distinguished gathering of Vice-Chancellors, Deans, Directors, and Executives and Officials of different agricultural organizations for deliberating important issues of managing agricultural wastes. At the outset, I in my own behalf and on behalf of Sardarkrushinagar Dantiwada Agricultural University whole heartedly thank to our Hon'ble Minister for Agriculture and Cooperation, Shri Bhupendrasinhji Chudasama for sharing his valuable time with us for guiding the course of this convention. I am specially thankful to Dr. K.C. Khandelwalji, Advisor, Non-conventional Energy Sources, Government of India for accepting our invitation and giving his consent for delivering Keynote address. I am also thankful to the functionary members of IAUA, President Dr. S.N. Puri ; Vice-President Dr. S.S. Magar ;Treasurer and Secretary, Dr. M.P. Yadav for choosing our university as venue of this prestigious convention.

I express my sincere gratitude to all the Vice-Chancellors, Deans, Directors and other officials of different Agricultural Universities of India for their participation in this convention.

Our beloved Vice-Chancellor Dr. B.S. Chundawat saheb is the guiding force behind organizing this mega event. We appreciate his keen interest in organizing this event and continuously encouraging one and all members of the organizing committee despite his ailing health for last few days.

I am highly thankful to the press and electronic media for being the witness of this important event and covering this convention during last couple of days. I am sure given the importance and prestige of the event the media will give due coverage to today's function.

I am specially thankful to Dr. S.B.S. Tikka, Director of Research and Organising Secretary, the conveners and members of various organizing committees, secretarial staff and supporting staff members for their constant endevour for making this event success.

I am also thankful to Jain Irrigation, Jalgaon and Agricultural Produce Marketing Committee, Unjha for their generous gestures.

Finally, I record my thanks from the canvas of my heart to whose names advertantly or in-advertantly have not found place in my acknowledgements due to paucity of time.

Thank you very much.

JAI HIND

Vote of Thanks

[illegible]

[illegible]

It is my privilege to propose a vote of thanks to this distinguished gathering. My [illegible] Directors, and Scientists and Officials of different [illegible] [illegible] [illegible] [illegible] [illegible] whose [illegible] [illegible] Minister for Agriculture and [illegible] [illegible] of this convention. I am especially thankful to Dr. R.D. [illegible], Adviser, Non-conventional Energy Sources, Government of India for accepting our invitation and giving his [illegible] for delivering keynote address. I am also thankful to the [illegible] President, Dr. [illegible] Vice-President Dr. S.S. Magar, Treasurer and Secretary Dr. [illegible] for their [illegible] [illegible] [illegible].

I express my sincere gratitude to the Vice-Chancellors, Deans, Directors and other officials [illegible] Agricultural Universities [illegible] participation in this convention.

[illegible] Dr. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

I am sure the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] convention [illegible] [illegible] days I [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] Dr. [illegible] Dean, Faculty of Agricultural Engineering and Technology [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] for their [illegible] [illegible] [illegible].

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Jai Hind

CITY WASTE WATER MANAGEMENT IN AGRICULTURE

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Shortage of energy, fertilizers and irrigation water are among the main problems facing the country today. Pollution of land, water and air through wastes generated as a result of increasing population, urbanization and industrialization is another challenge of serious dimensions. Urbanization and industrialization lead to the generation of large volumes of waste water from domestic, commercial, industrial and other sources. Indiscriminate discharge of such waste waters into natural water courses, such as rivers, lakes and sea is likely to pollute them to such an extent that the water would become unfit for further use. Sewage from most of the urban centres in India is discharged after partial treatment or no treatment at all. The increased tempo of industrial activity has resulted in a large number of industries discharging liquid effluent with or without treatment. Several of the industrial effluents which are biodegradable could be treated separately or in combination with domestic sewage and utilized for agriculture, Heavy metals, salt, organic chemicals and/or pathogens can have adverse effects on the environment and human health as well as crop quality and yield. Recycling of the wastes into resource materials would not only boost agricultural production, but would also minimize the spread of communicable diseases.

Nature and availability of city waste water

City waste water comprises more than 90 per cent water. It carries along a variety of organic and inorganic substances and also various micro-organisms, mostly of human origin. The concentration of sewage depends primarily on the per capita water supply of the community as also on the habits of the people with regard to food and sanitation.

A project on the utilization of city waste water as a nutrient source was started in India in 1896 when one of the first sewage farms was established in Ahmedabad. The availability of waste waters of domestic origin is about 10 million m3/day, while sewage production potentials of 1000 million gallons/day in India. There is a waste water discharge at the rate of 182 litre/capita/day with a nutrient concentration of N-100, P_2O_5 - 40 and K_2O - 70 mg/litre in the cities of our country.

It has been calculated that sewage available from big cities in India could annually contribute 33,000 tonnes of N, 7000 tonens of P and 20,000 tonnes of K (Anonymous, 1992). According to the estimate by Perumal and Mahim Raja (1991) sewage sludge from Urban areas can provide for 1.2, 1.0, 0.8 million tonnes of N, P and K, respectively. An estimated 162.7 million litres of untreated sewage produced in Haryana per day could be utilized directly, without pretreatment for irrigating 3345 ha of vegetable crops, 5017 ha of fodder crops or 4459 ha of cereal crops (Baddesha et al., 1986). Five irrigations of 7.5 cm ha^{-1} each with sewage would provide 181, 28, 270, 130, 1.3, 0.8, 41.8 and 1.4 kg ha^{-1} N, P, K, S, Zn,

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Cu, Fe and Mn, respectively.

Major problems associated with utilization of city waste water

i) Pathogenicity of waste water

The effect of land application of waste water on human health is a matter of concerns, as it contains human pathogens, some of which may survive in soil for only a few days while others may survive for six or more months (Burge and Enkiri, 1978). The health risks would be considerably greater with raw sewage waste water containing residual pathogenic viruses, bacteria, cysts of protozoa and ova of healminths. The major pathogens found in such waters and the infectious disease hazards associated with the pathogens are enlisted in Table 1.

Several methods are available for disinfection of waste water effluents. Chlorination is one of the important methods, which is one of the important methods, which is seldom complete. Data presented in Table 2 gives an idea of the extent to which pathogenic microorganisms can be removed by these treatment processes. Usually, the soil functions as a filter and the microbes in the sewage are retained in its top layers. They do not travel long horizontal distances except in certain hydro-geological situations like limestone formations where microbes are transported to long distances.

Regulations on sewage disposal and utilization

Some of the constraints associated with city waste water management can be eliminated by imposing necessary regulations. Many national and international regulations have been formulated to specify restrictions on the disposal and utility aspects of waste water. The international regulations on the application of waste water to crops and crop lands have been reviewed by Pounds and Crites (1973) and Parson *et al.* (1975). In countries like Israel the sewage water has been brought to drinking water quality and is pumped to distant desert areas for increasing agricultural production. Treated sewage water is considered one of the water resources for irrigation in Israel. In India, the State water pollution control boards and departments of health issue periodic notifications in respect of the preventive measures to be taken against pollution through the disposal of industrial and municipal liquid wastes. A status report has been prepared by the Central Board for prevention and control of water pollution, in collaboration with the Centre for environmental studies, Jadavpur University, which emphasizes that a precondition for effective water pollution control is the provision of adequate facilities for collection, treatment and disposal of both solid and liquid wastes which otherwise pollute the natural water courses (Anonymous, 1974). Pavanello and Mohanrao (1973) have suggested measures for overcoming water pollution problems related to sewage disposal systems used in developing countries like India. The general standards for discharge of effluents discharge into inland surface waters and that drinking water specification are given in Table 3, 4 and 5, respectively.

ii) Heavy metals

The distribution of pollutant metals in the vegetables grown in the area irrigated with sewage water of Calcutta city is given in Table 6 by Pathak and Joshi (2001).

Field survey for assessing ground water quality and salinity build up in irrigated soils of Sikandarabad area of Bulandshahar district of U.P. as influenced by irrigation with industrial effluent of various industries was carried out during June, 1995 by Ashok Kumar *et al.*, (1998). Samples of effluent, surface and subsurface ground water from ponds, hand pumps and tubewells and soil samples from irrigated fields were collected and analysed for different characteristics. The indiscriminate disposal of the effluent of this industrial complex has aggravated the salinity and sodicity problem in the irrigated soils and shallow surface water resources like ponds. Organic carbon is increased 2 to 3 times as compared with that of adjoining normal soils. Of the industrial effluents, that from tannery industry are a dangerous pollutant, tanneries discharge huge quantities of water. The untreated tannery effluent, containing mainly of tannins, depletes oxygen level and exerts high BOD and COD and causes enormous damage to crops. Effect of tanliquor and tannin on soil properties is given in Table 7 by Sivaswamy (1990).

When the solids are removed from waste waters, the heavy metal contents are reduced significantly in the waste water. A part of the heavy metals get attracted for the negatively charged colloids. That is why plants growing in the fields absorb very little heavy metals from the waste waters. In studies at Hissar in Haryana, among non-essential heavy metals added at the rate of 40 ppm, lead and nickel had the least adverse effect on the yield of green gram, black gram and pigeonpea, while cadmium and mercury were most toxic (Gupta et al., 1994). Experiments indicate that plants can be harmed when their levels in the soil are greater than 3 ppm water extractable B, 30 ppm EDTA extractable Cu, 200 ppm acetic acid extractable Zn and 20 ppm acetic acid-extractable Cd. (Purves, 1977).

Patel *et al.* (2004) studied the effect of heavy metal content of different effluents and their relative availability in soil irrigated with effluent waters around major industrial cities from Gujrat. The effluent and well water samples from surrounding industries were analysed for their suitability for irrigation purpose.

Waste water Treatments

The treatment given to sewage wastes may be primary or secondary or both (Vimal and Talashilkar, 1985). The primary treatment includes screening, grit removal, coagulation, sedimentation, sludge digestion and sludge disposal. Secondary treatment consists of biochemical oxidation of the effluent from the primary treatment processes. This is done as biological filtration, activated sludge or other forms of biochemical oxidation. This treatment aims at removing dissolved and colloidal organic matter contained in the sewage wastes, by making use of naturally occurring microorganisms.

The convential methods used for the treatment of sewage are required to satisfy the British Royal Commission, 'Standards' soluble salts 30 ppm and BOD 20 ppm. An additional treatment referred to as 'polishing' or 'tertiary' treatment is also given to remove suspended and dissolved materials and contaminants not removed by primary and secondary treatment or by natural stream purification.

Oxidation ponds provide a practical means of treating sewage and certain other wastes. Over 31 types of industrial wastes are treated by the waste stabilization pond process (Chaney, 1975). Organic matter is removed from the oxidation pond through the metabolic action of the major group of microbes which oxidize organic materials for energy and photosynthetic algae, which fix CO_2 for carbon and derive energy from sunlight.

Effect of waste water on soil properties and crop yields

The use of sewage water in agriculture saves on fertilizer and irrigation costs. For the improvement of soil fertility, optimum plants growth and best yields, the farm should be supplied with water and nutrients as per the requirements of the crops. Judicious use of sewage water for cultivation of cereals, vegetables, fruit trees and fodder crops is found to be successful in Australia, China, Germany, Mexico, Tunisia, USA and India (WHO, 1988). The cropping pattern suggested for irrigation with treated sewage is given in Table 8.

The influence of waste water treatment on physico-chemical characteristics of soils is studied by many workers (Table 9 and 10). The chemical composition of crops fed on sewage-treated soil in the Calcutta and other parts of country showed high concentration of N and Ca, moderate levels of P, S and Mg. The higher levels of micronutrients are also depicted in different crops.

Saha and Mandal (1996) studied the effect of sewage effluent on the transformation of organic N in sewage-fed fish pond soil from West Bengal. The results of an experiment revealed that available N content of the soil did not show any appreciable change with the application of sewage effluent and recorded similar trend of variation as control.

Several researchers have reported positive effect of sewage on crop yield (Gupta *et al.*, 1993; Juwarkar *et al.* 1994; Nagaraja and Krishnamurthy, 1989). Application of primary treated sewage increased yield of rice by 12% and wheat by 24% compared to irrigation with well water. Similar increase in yields of pulses, vegetables and flowers were also observed (Table11). The highest yields were obtained with primary treated sewage followed by diluted sewage (sewage diluted with water in 1:1), untreated sewage and well water. Chakrabarti (1995) also found positive effect of sewage application of a period of 10 years on wheat, rice and green gram at Nagpur. Mahida (1981) obtained higher yields of vegetables irrigated with undiluted sewage compared to irrigation with canal water (Table 12). Sewage diluted with canal water in 1:1 also recorded higher yields of vegetables except carrot and radish. Haroon and Ramulu (1990) at Mudurai, Tamil Nadu, observed that sewage application increased yields of okra, amaranthus and onion. Singh *et al.*, (1995) at Rishikesh, Uttar Pradesh, obtained highest yields of sorghum, maize and cowpea with treated sewage irrigation than irrigation with tube well water. Total N and P uptake by wheat increased with increased application of sewage (Gupta *et al.*, 1993 and Prasad, 1996). An increase in the concentration of Cu, Zn, Cr and Mn was also observed in wheat plant. Tripathi *et al.*, (1988) recorded maximum yield of potato with treated sewage irrigation followed by raw sewage and tube well water irrigation.

Potential for practical application of sewage and constraints

Application of sewage on land is comparatively easy and is usually practiced in the outskirts of cities. The raw or treated sewage is pumped and conveyed through pipes to different areas of the farms where it is directed to the plants through ridges and furrows or by flooding. It is advantageous to the plants since nutrients and water are made available to plants in a single operation. The system has the disadvantage of the farm workers coming in contact with the aerosols and the sewage which may contain the viable pathogens, Experience with sewage farming in the Nagpur area in Central India showed that excessive application of sewage is common. Farmers tend to do this as they are charged on area basis and not on the amount of sewage used (Juwarkar, 1991). As a result, N application rates can reach 900-1500 kg/ha which are not only far above the crop requirement but also of the soils retention capacity. Such practices can lead to ground water pollution and in certain cases to soil sickness as well. There is thus a need to refine the management practices for recycling human wastes in farming. For the most beneficial recycling of human wastes, these should be used according to the degree of treatment for different crop species. These essentially indicate that plant products which are directly consumed by humans should be grown with sewage which has at least received secondary treatment. The optimum rates and intervals of sewage application to agricultural soils should be determined by primarily by crop needs and soil health considerations and not merely as an outlet for waste disposal.

The methodologies for sewage treatment are quite well established. Under optimum operational conditions and efficient management the pathogenic organisms can be killed or physically removed. However, in many places, the treatment and management are not given priority, resulting in the pathogens reaching the farms. Biological control of pathogens is an area which holds a lot of promise. We have to develop microorganisms which are not pathogenic to man, but can attack the pathogenic forms in soil and disintegrate them in a few days. A proteolytic fungus which can penetrate the Ascaris eggs in soil and make it non-viable can be quoted as an example.

Very little is known about the potential risk of viral contamination of ground water associated with on-site sanitation systems. Sewage contains nutrients for plants and should support all types of plants including forest trees. Development of avenues, gardens and forests with waste waters is a less explored area. There are no published guidelines for the classification of hydrogeological environments in relation to pollution risk. This would be of great value in the appraisal and implementation of onsite sanitation schemes.

Utilization of waste water for Pisciculture

The nutrients in the waste water are of immense value in aquaculture for growth and multiplication of bacteria who in turn promote the growth of phytoplankton and zooplankton which are essential for fish growth (Mandal and Chattopadhyay, 1992). The sewage is applied in ponds and other water bodies to culture fishes, notably common carp *(Cyprinus carpio)*, Indian major carp (Catla, mrigal and rohu) and Tilapia *(Oreochromis mossambicus)*. According to the recent reports two thirds of the world yield of farmed fish is obtained from ponds fertilized with sewage and animal manure (WHO, 1989).

In China, the use of excreta in aquaculture is integrated with agriculture as primary, secondary or a side activity based on the availability of land and water resources. This results in a full use of raw materials available for the production of cheapest source of proteins. The excreta and other waste materials are used to fertilize ponds and croplands from where fish and food crops are produced. China produces 2.25 million tonnes of farmed fish per year from 7000 sq.km. of ponds compared to 1.5 m.t. per year from 18000 sq.km. of ponds in the rest of the world. The average yield from fish ponds in China is 3200 kg/ha per year which could be increased to 7000 kg/ha per year in well managed polyculture ponds (Tandon, 1995). In India, the ponds are fed with raw waste water from Calcutta. The largest among these ponds covering 4400 ha exists in Calcutta and is stocked with Indian major carp and tilapia. The mean annual yields are approximately 1000 - 1400 kg ha^{-1}. The fishes have also been raised very successfully in waste stabilization ponds with an annual yield of upto 3000 kg/ha/ year (WHO, 1989). Experiments were conducted at the Central Inland Fisheries Research Institute from West Bengal to ascertain the possibility of culture of the fish Tilapia mossambico in a sewage-fed pond of 22,00,000 litre/ha where the effluent was diluted with fresh water in the ratio of 1 : 3. A net production of about 9000 kg/ha/year was achieved (Ghosh, 1976). In order to prevent the contamination in fishes, it is suggested that fishes be held in fresh water immediately after harvest for at least a few hours for them to evacuate their intestines.

Recommendations for use of waste water

1. The practice of sewage irrigation in agriculture should be standardised on the basis of soil, weather and crop characteristics, indiscriminate and blanket use may lead to adverse effect on the long-term.

2. Quality of sewage plays an important role for its use as a source of nutrient. Therefore, regular monitoring of the quality of sewage should be done and threshold limit of sewage application should be estimated based on its quality.
3. Treatment of sewage should be made mandatory for its use in agriculture.
4. In most of our cities domestic sewage is mixed with industrial effluents, which contains very high concentrations of toxic metals. Therefore, domestic sewage and industrial wastes should be treated separately and different standards should be developed for their use in agriculture.
5. The farms using sewage for irrigation should be regularly monitored for the content of heavy metals and pathogens.

Conclusions

Use of sewage for irrigation has gained importance throughout the world due to limited water sources and costly treatment of wastewater for discharge. If land with suitable topography, soil characteristics and drainage is available, sewage effluent can be put to good use as a source of both irrigation water and plant nutrients. Potential benefits of this practice include reduced cost of treatment and energy inputs and reduction or elimination of problems related to sewage handling, storage and disposal. Studies indicated that five irrigations of 7.5 cm ha-1 each with sewage would provide 181, 28 and 270 kg/ha N, P and K, respectively and considerable amount of secondary and micronutrients. Application of sewage increased yield of crops compared to irrigation with fresh water. Application of sewage increased total N, P, K and organic carbon contents of soil, reduced the bulk density with concomitant increase in hydraulic conductivity, pore space and increased bacterial and fungal populations in soil resulting in higher microbial activity. However, potential hazard due to heavy metal pollution, eutrophication, groundnut water contamination by nitrate and health risks for pathogens is of concern. To combat such problems several techniques have been developed for sewage treatment and disinfection. In a country like India encountering the problems of water scarcity and high cost of fertilizer, sewage, can be successfully used for irrigation. Moreover, it might be better to dispose the sewage on soil rather than dumping it in water bodies, which are more susceptible to resulting pollution. Soil, with various physico-chemical and microbiological processes operating in it can transport, transform and destroy the hazardous components of sewage and reduce its adverse effects.

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Table 1. Major pathogens and associated diseases present in sewaget

	Organism	Disease
Bacteria	*Salmonella spp.*	Salmonellosis
	Mycobacterium tuberculosis	Pulmonary tuberculosis
Protozoa	*Entamoeba histolytica*	Amoebic dysentery
	Helminthic parasites	
	Ascaris lumbericoides	Ascariasis
Virus	*Polio virus*	Poliomyces
	Coxsickie virus	Gastroenteritis
	Hepatitus virus	Infectious hepatitis
	Revovirus	Mild respiratory infections

(Burge and Enkiri,1978)

Table 2. A comparison of per cent removal of cysts and eggs of enteric parasites in various sewage treatment processes

Parasite	Sedimen tation	Activated sludge	Trickling filterz	Biological Disc	Aerated lagoon	Oxidation ditch	Stabiliza tion pond
E. histolytica	63.7	82.9	91.0	69.6	84.0	91.3	100
G. lamblia	51.7	92.0	92.5	58.4	86.5	91.0	100
A. lumbericoides	96.2	97.9	94.8	79.2	92.0	94.3	100
Hook worm	80.0	85.0	81.8	50.0	70.0	81.3	100
H. nana	90.0	95.0	80.0	60.0	77.8	88.9	100
T. trichiura	90.0	100	92.5	60.0	100	100	100
Taenia spp.	75.0	*	*	*	100	100	100

* Not detected in raw sewage. (Panicker and Krishnamurthy, 1978)

Table 3. General Standards for Discharge of Effluents Discharge Into Inland Surface Water (As per Schedule VI of G.S.R. 422 (E))

Sr. No.	Parameter	Standard
1.	Colour and Odour	Removed as far as practicable
2.	pH value	5.5 to 9.0
3.	Temperature	20^0 C
4.	Particle size of the suspended solids	Shall pass 850 microns/ S Seive
	All the values expressed in mg/l, maximum unless specified	
5.	Suspended solids	100
6.	Dissolved solids (Inorganic)	2100
7.	Oil and Grease	10
8.	Total residual chlorine	1.0
9.	Ammonical Nitrogen (as N)	50
10.	Total Kjeldhal Nitrogen (as NH3)	100
11.	Free Ammonia (as NH3)	5.0
12.	Biochemical Oxygen Demand	30
13.	Chemical Oxygen Demand	250
14.	Arsenic (as As)	0.2
15.	Mercury (as Hg)	0.01
16.	Lead (as Pb)	0.1
17.	Cadmium (as Cd)	2.0
18.	Hexavalent Chromium (as Cr+6)	0.1
19.	Total Chromium (as Cr)	2.0
20.	Copper (as Cu)	3.0
21.	Zinc (as Zn)	5.0
22.	Selenium (as Se)	0.05
23.	Nickel (as Ni)	3.0
24.	Boron (as B)	2.0
25.	Cyanide (as Cn)	0.2
26.	Chloride (as Cl)	1000
27.	Fluoride (as F)	2.0
28.	Dissolved phosphates (as P)	5.0
29.	Sulphates (as SO4)	1000
30.	Sulphide (as S)	2.0

Table 4. Classification of inland surface water (CPCB STANDARD)

	Characteristics	A@	B@	C@	D@	E@
1.	Dissolved Oxygen, mg/l, Min.	6	5	4	4	--
2.	Biochemical oxygen Demand, mg/l, Max	2	3	3	--	--
3.	Total Coliform organisms, MPN/100 ml Max.	50	500	5000	--	--
4.	Total Dissolved Solids, mg/l Max.	500	--	1500	--	2100
5.	Chlorides (as Cl) mg/l Max.	250	--	600	--	600
6.	Colour, Hazen units, Max	10	300	300	--	--
7.	Sodium adsorption ratio, max	--	--	--	--	26
8.	Boron (as B), mg/l, Max	--	--	--	--	2
9.	Sulphate (as SO4), mg/l, max	400	--	400	--	1000
10.	Nitrates (as NO3), mg/l, max	20	--	50	--	--
11.	Free Amonia (as N), mg/l, Max	--	--	--	1.2	--
12.	Conductivity as 2500 C, micromhos cm, Max	--	--	--	1.0	2.25
13.	pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.0
14.	Arsenic (as As) mg/l, Max	0.05	0.2	0.2	--	--
15.	Iron (as Fe) mg/l, max	0.3	--	50	--	--
16.	Fluorides (as F) mg/l, Max	1.5	1.5	1.5	--	----
17.	Lead (as Pb), mg/l, Max	0.1	--	0.1	--	--
18.	Copper (as Cu) mg/l, Max	1.5	--	1.5	--	--
19.	Zinc (as Zn), Max	15	--	15	--	--

A@ - Drinking water source without conventional treatment but after disinfection

B@ - Outdoor bathing (organized)

C@ - Drinking water source with conventional treatment followed by disinfection

D@ - propagation of wild life, Fisheries

E@ - Irrigation, Industrial cooling, controlled waste disposal.

Table 5. Drinking Water Specifiation : IS : 10500, 1992 (Reaffirmed 1993)

Parameter	TOLERANCE LIMITS IS : 10500 Requirement (Desirable limit)	Undesirable effect outside the desirable limit	IS : 10500 Permissible limit in the absence of alternate source
Essential characteristics			
1. pH	6.5 - 8.5	Beyond this range the water will effect the mucous membrane and/or water supply system	No relaxation
2. Colour (Hasen Units Maximum	5	Above 5, consumer acceptance decreases	25
3. Odour	Unobjectionable	---	---
4. Taste	Agreeable	---	---
5. Turbidity, NTU, Max	5	Above 5, consumer acceptance decreases	10
Following Results are expressed in mg/l			
6. Total hardness as $CaCO_3$, Max	300	Encrustation in water supply structure and adverse effects on domestic use	600
7. Iron as Fe, Max	0.3	Beyond this limit taste/ appearance are affected has adverse effect on domestic uses and water supply structures, and promotes iron bacteria	1.0
8. Chlorides as Cl, Max	250	Beyond this limit taste, corrosion and palatability are effected	1000
9. Residual, free chlorine, Min.	0.2	---	---

Cont...

Desirable characteristics

10. Dissolved solids, Max	500	Beyond this palatability decreases and may cause gastro intentional irritation	2000
11. Calcium as Ca, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
12. Magnesium as Mg, Max	30	--	100
13. Copper as Cu, Max	0.05	Astringent taste discoloration and corrosion of pie, tilting and utensils will be caused beyond this	1.5
14. Maganese as Mn, Max	0.1	Beyond this limit taste/ appearance are affected as adverse effect on domestic uses and water supply structures	0.3
15. Sulphur as SO_4, Max	200	Beyond this causes gastro intentional irritation when magnesium or sodium are present	400
16. Nitrates as NO_3	45	Beyond this methane moglobinemia takes place	100
17. Fluoride as F, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5
18. Phenolic compounds as C_6H_5OH, Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002

Table 6. Composition of sewage

Parameters	Juwarkar (1987)	Chakrabarti & Chakrabarti (1988)	Som et al., (1994)	Adhikari et al., (1997)
Location	Nagpur	Nagpur	Calcutta	Calcutta
N (mg 1^{-1})	55-68	5-15		20
P (mg 1^{-1})	8-13	1-2	2-7	2
Organic C (%)	20-30			
HCO-3 (mg 1^{-1})	300-390			61
Cl- (mg 1^{-1})	64-110		3-4	205
Ca2+(mg 1^{-1})	1-3		3-4	86
Mg2+ (mg 1^{-1})	20-32		1-2	36
Na+ (mg 1^{-1})	93-134		4-7	126
K+ (mg 1^{-1})	10-16	13-19	14-20	19
Fe (mg 1^{-1})		18-24		
Zn (mg 1^{-1})		90-110	67-74	
Mn (ìg 1^{-1})		240-260		
Cu (ìg 1^{-1})		52-58		
Pb (ìg 1^{-1})			25-38	8
Cr (ìg 1^{-1})		70-80	6.4-7.1	1
Ni (ìg 1^{-1})				8
Cd (ìg 1^{-1})			4-25	
Co (ìg 1^{-1})				3
pH	7-8	4-11	7-8	8
EC (dS m^{-1})	0.7-1.0	0.6-1.0	1-2	1.2
SAR	7.5-8.4		1.3-2.9	2.9

(Pathak and Joshi, 2001)

Table 7. Effect of tanliquor and tannin on soil properties

Treatment	pH	EC (dS m^{-1})	N	P (kg acre^{-1})	K	Cu	Fe (ppm)	Mn	Zn	Phenols O.D.	Phenols Total
Control	7.7	0.1	73	5	32	1.0	9.5	9.70	1.5	5.59	18.88
Tanliquor	7.4	0.1	70	23	41	1.1	10.5	27.90	0.4	5.76	17.12
Control	7.0	0.7	84	6.7	109	5.8	2.5	24.70	103.6	--	--
Tannin	6.6	0.7	99	8.7	204	0.1	0.1	238.50	112.4	--	--

(Siwaswamy, 1990)

Table 8. Crops suitable sewage amended fields

Treatment level	Type of crops	Crops in order of preference
Primary treated sewage	Cash crops	Cotton, jute, sugarcane, tobacco
	Essential oil crops	Citronella, mentha, lemon grass
	Cereals and pulses	Wheat, rice, green gram, black gram, sorghum, pearl millet
	Oil seeds	Linseed, sesame, castor, sunflower, soybean, groundnut
	Fruit crops	Coconut, banana, citrus, sapota, guava, grapes, papaya, mango
	Vegetables	Brinjal, beans, ladies finger
Secondary treated sewage		All crops listed above and vegetables borne near the soil surface
Disinfected sewage		All crops without restriction

(Juwarkar, 1991)

Table 9. Chemical characteristics of the irrigated soil

Characteristics	Range		
	Pond	Hand pump	Tube well
pH	7.1 - 9.2	7.1 - 9.8	7.3 - 9.5
EC (dS m^{-1})	1.0 - 10.2	1.2 - 9.0	1.1 - 9.6
Cl- (cmol L^{-1})	2.9 - 13.0	3.6 - 21.6	2.9 - 13.6
CO32- (cmol L^{-1})	0.0 - 3.8	0.0 - 0.8	0.0 - 0.0
HCO-3 (cmol L^{-1})	3.1 - 9.6	2.7 - 6.5	3.1 - 6.5
Ca2+ (cmol L^{-1})	18.8 - 178.6	11.3 - 146.7	7.5 - 127.9
Mg2+(cmol L^{-1})	7.5 - 83.7	3.8 - 101.0	7.5 - 102.6
K+(cmol L^{-1})	0.5 - 65.0	0.5 - 21.5	1.0 - 13.8
Na+(cmol L^{-1})	8.0 - 275.0	6.5 - 240.0	7.0 - 360.0
Copper (mg kg^{-1})	0.9 - 6.9	0.2 - 6.0	0.9 - 3.9
Zinc (mg kg^{-1})	0.5 - 8.9	0.3 - 1.3	0.3 - 1.6
Manganese (mg kg^{-1})	12.2 - 109.8	11.1 - 109.7	10.7 - 148.0
Iron (mg kg^{-1})	11.0 - 156.8	14.8 - 63.4	12.5 - 58.0
Organic carbon (g kg^{-1})	Tr - 23.0	2.0 - 19.0	2.0 - 16.0

(Pathak and Joshi, 2001)

Table.10 Effect of irrigation for eight years with differentially diluted raw sewage on soil properties

Treatment	Sewage (undiluted)	66% sewage (2:1 dilution)	50% sewage (1:1 dilution)	33% sewage (1:2 dilution)	Well water
pH (1:2)	8.50	8.87	8.93	8.88	9.00
EC (1:2) dS m^{-1}	0.23	0.24	0.26	0.25	0.27
ESP	7.68	8.51	9.58	8.61	11.76
Total N (%)	0.14	0.13	0.12	0.11	0.09
Total P (%)	0.05	0.04	0.04	0.04	0.03
Total K (%)	0.50	0.48	0.47	0.43	0.39
Organic C (%)	1.00	0.70	0.65	0.62	0.57

(Shende *et al.*, 1988)

Table 11. Crop yield with sewage amendment of soil

Crops	Yields (t/ha)			
	Well water	Untreated sewage	Primary treated sewage	Diluted (1:1) sewage
Rice	3.8	3.3	4.3	4.1
Wheat	2.8	3.1	3.4	3.2
Soybean	1.6	2.1	2.3	1.9
Greengram	0.6	0.5	0.8	0.7
Chickpea	1.2	1.3	1.5	1.4
Cabbage	13.3	14.8	16.4	15.7
Cauliflower	16.4	18.2	19.7	16.9
Okra	3.1	3.4	4.8	4.0
Tomato	13.7	15.5	16.4	16.1
Brinjal	9.1	12.1	12.7	10.7
Potato	6.4	7.1	8.1	7.1
Sugarcane	42.7	44.4	48.5	43.3
Marigold	5.1	7.1	7.6	--
Daizy	8.4	9.7	11.4	--
Jasmin	3.7	3.4	4.4	4.1

(Juwekar *et al.*, 1994)

Table 12. Yields of vegetables irrigated with sewage

Crop	Yield (t/ha)		
	Undiluted sewage	Diluted (1:1) sewage	Canal water
Beet root	16.27	15.60	8.75
Carrot	11.75	8.72	9.71
Radish	8.33	6.14	7.26
Potato	9.33	7.00	6.12
Ginger	9.80	9.18	6.04
Papaya	37.00	27.91	26.72
Knolkhol	16.57	11.76	9.70
Cabbage	12.13	11.32	7.27
Cauliflower	9.09	7.08	6.96
French beans	8.06	8.20	6.63
Tomato	13.38	--	10.01
Tobacco	1.25	1.25	1.12
Groundnut	2.90	2.90	2.88

(Mahida, 1981)

COMPOSTING-A SMART BUSINESS APPROACH FOR WASTE MANAGEMENT IN SUGAR INDUSTRY

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The Sugar Industry follows textile manufacturing to be the second largest agriprocessing sector in India. A typical sugar and distillery complex generates large quantities of wastes like bagasse, pressmud, molasses and distillery spentwash. Bagasse is a solid waste of the sugar mill that is typically used as fuel in boilers for power generation. Molasses is a liquid by-product that is utilized as a fermentation substrate for production of ethanol for industrial and potable uses. Until recently, the sugar factory pressmud and distillery spentwash were considered as wastes. The scope for recycling these wastes in agriculture is vast by any standards, and the enromous potential that they offer in the production of compost has only been recently realized.

Recognizing the importance of organic additives in sustainable agriculture, a commercially viable, large-scale composting technology based on principles of "Aerobic Microbial Solid State Fermentation" was developed to convert sugar industry wastes into nutrient rich ecofriendly compost.

In the present scenario, with increasing need to conserve natural resources and prevent pollution problems, the innovative use of sugar industry wastes such as pressmud and distillery spentwash for the production of compost assumes greater importance.

PRESSMUD

A by-product from clarification of sugarcane juice, pressmud consists primarily of sugar, fiber and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles. As the constituents of pressmud have been derived only from sugarcane, it does not contain any toxic substances that may be harmful to soils. In India, around 220 million tons of sugarcane is produced annually and sugar mills crush 61.6 percent of this cane to produce sugar. Typically pressmud production is 3.5 percent of total cane crushed resulting in an annual production of about 5 million tons of pressmud. Pressmud is a finely pulverized organic material with high nutrient concentrations (Table 1).

The composition and properties of pressmud vary depending upon the quality of cane and the process followed for the clarification of cane juice in a sugar factory. Pressmud has in the past been used mainly as (1) a source of plant nutrients and (2) an amendment to marginal soils. However, direct application of pressmud to the soil has been criticised because of the high was content (8-15 percent by weight) in it that could impact soil physical properties. Composting of pressmud before application to the soil could remove this drawback and has been suggested as a beneficial alternative process.

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DISTILLERY SPENTWASH

There are about 329 distilleries in India producing a combined total of over a billion liters of effluent (distillery spentwash) annually. Spentwash is a dark colored, acidic, high strength (BOD: 40,000 to 80,000 mg/L) liquid consisting primarily of biodegradable organics and some inorganic constituents. Because of its high strength and acidic nature, environmental regulations require intensive treatment of spentwash before discharge or reuse. Spentwash has been a cause of concern in many parts of the world for the past few decades and various disposal techniques have been developed and evaluated over the past 40 years. In the recent past it has been proven that distillery spentwash can be a valuable by-product generated from distilleries because it is essentially a plant extract derived from sugarcane and contains nutrients and organic matter that could be returned to the soils. Spentwash is a rich source of organic matter and nutrients like nitrogen, phosphorus, potassium, calcium and sulfur (Table 2). In addition it contains sufficient micronutrients such as iron, zinc, copper, manganese, boron and molybdenum.

In contrast to most industrial effluents, distillery spentwash does not contain any toxic heavy metals or hazardous constituents. After realizing the value of the distillery spentwash and its importance as an organic input for sustainable agriculture, a large-scale, commercially viable "Composting Technology" was developed. This technique uses the principles of solid-state fermentation for treating distillery spentwash comprehensively and economically. Through the utilization of this approach, many sugar mill complexes attached with distilleries in India achieve zero liquid discharge while returning to the earth those elements that were absorbed by sugarcane during its growth.

Table 1. Composition of Pressmud

Parameters	Values
Organic carbon	34.50 - 41.90 %
Nitrogen	0.47 - 1.05 %
Phosphorus	2.31 - 3.01 %
Potassium	0.48 - 0.84 %
Calcium	0.83 - 1.98 %
Magnesium	0.05 - 0.25 %
Sulphur	0.22 - 0.31 %
Copper	35 - 200 mg / kg.
Zinc	47 - 215 mg / kg
Manganese	163 - 215 mg / kg
Iron	250 - 9500 mg/kg
pH	6.5 - 7.0

THE COMPOSTING SYSTEM

In this process, a mixed population of microorganisms decomposes organic matter in a moist aerobic environment within a solid matrix. The process developed at Rajshree Sugars has two unique features distinguishing it from conventional windrow composting. First is the use of a specially developed enriched microbial consortium containing bacteria, actinomycetes and fungi that rapidly degrade spentwash. The second is the use of a special purpose windrow turner. This machine agitates, aerates and shreds the composting mass and facilitates spreading the microbial inoculum uniformly over the entire length of windrows.

Pressmud is received from the sugar mill in trucks and formed into windrows that are 1.5 m high and 4.0 m wide at the base. Windrows are sprayed with measured quantities of distillery spentwash where the pressmud acts as a solid matrix absorbent. The ratio of distillery effluent to pressmud in the composting mixture is usually about 2.5 to 3.5:1 (wet weight basis). Windrows are inoculated with the microbial starter culture (0.1 percent by weight and the application of distillery spentwash over windrows is carried out at specific intervals for 9 to 10 weeks. The windrow turner tills the windrows at least five times a week followed by spentwash application. The tilling operation breaks clumps of pressmud into uniform fine particle size thereby increasing the surface area and assisting spentwash absorption. Windrow mixing also provides oxygen to microorganisms and helps dissipate the heat and moisture that exist in the windrows. In addition, mixing serves to remove toxic gases such as carbon dioxide and ammonia. The entire composting process requires 12 to 13 weeks depending on ambient conditions (Table 3).

Typically during composting, windrow temperatures rise to 70°C during the initial weeks and remain between 50 and 70°C for a period of 9 to 10 weeks. The rate of temperature increase and the length of the period where temperatures are above 50°C are used in process management as indicators of compost activity and final stability. During the process, the C:N ratio decreases significantly, while the moisture content is maintained between 50 and 60 percent by the application of spentwash. A stable compost product is obtained after 12 weeks of processing and has typical characteristics as shown in Table 4. The maturity of the final product is evaluated to assess the state of decomposition and the suitability of the compost as a medium for plant growth.

ADVANTAGES AND CONSTRAINTS IN COMPOSTING TECHNOLOGY

Composting is an integrated treatment technology to convert organic wastes into a value-added product. Despite the heavy organic loading of spentwash, the process allows sustained abatement of pollution through "Zero Liquid Discharge" and eliminates the need for primary treatment of distillery effluent. The end product formed in this process is no longer a waste but is a nutrient-rich compost that can improve soil fertility and agricultural productivity. Implementation of this technology has promoted the 4R strategies of reduce, reuse, recover and recycle wastes to conserve resources and prevent pollution.

Although the technology has been successfully demonstrated, there are issues faced by many sugar complexes that may not allow them to immediately implement composting. The author identified the following six issues as limitations to implementing this approach to all sugar complexes nationwide:

Table 2. Characteristics of Distillery Spentwash from Different Manufacturing Processes in India

Parameter	Batch Process	Cascade Process	Biostil Process
Volume, L/L alcohol	14-16	11-13	6-8
pH	3.7 - 4.5	4.0 - 4.3	4.0 - 4.2
COD	80,000 - 1,10,000	1,10,000 - 1,30,000	1,50,000 - 2,00,000
BOD	45,000 - 50,000	55,000 - 65,000	70,000 - 80,000
Total solids	90,000 - 1,20,000	1,30,000 - 1,60,000	1,60,000 - 2,10,000
Total volatile solids	60,000 - 70,000	60,000 - 75,000	80,000 - 90,000
Inorganic dissolved solids	30,000 - 40,000	35,000 - 45,000	60,000 - 90,000
Chlorides	5,000 - 6,000	6,000 - 7,500	10,000 - 12,000
Sulphates	4,000 - 8,000	4,500 - 8,500	8,000 - 10,000
Total nitrogen	1,000 - 2,000	1,000 - 1,400	2,000- 2,500
Potassium	8,000 - 12,000	10,000 - 14,000	20,000 - 22,000
Phospohorus	200 - 300	300 - 500	1,600 - 2,000
Sodium	400 - 600	1,400 - 1,500	1,200 - 1,500
Calcium	2000 - 3,500	4,500 - 6,000	5,000 - 6,500

* all values are in mg/l except pH

Table 3. Composting Process - Activity Schedule

Week	Activity
1	Windrow formation with pressmud Natural drying to bring down the moisture of pressmud below 60 percent
2-10	Microbial starter culture inoculation Distillery spentwash application to maintain moisture content at 50-60 percentTrimming & tilling
11-12	Curing Trimming & tilling to bring down the moisture content of compost below35 percent
13	Quality testing of compost Removal of windrowsBagging and despatch

1. Availability of adequate quantity of pressmud or alternate compostable absorbent
2. Availability of adequate land area for composting
3. Ability to locate the compost yard away from public dwelling places
4. Cost constraints to provide impervious flooring for compost yard
5. Management of the composting operations during monsoon seasons
6. Provision of leakproof storage tanks for storing spentwash and rainwater leachate.

BENEFITS OF PRESSMUD BASED COMPOST :

Pressmud based compost is used as a soil conditioner for agricultural and horticultural crops. Apart from improving organic matter content of the soil, it provides nutrients that were depleted from agricultural fields due to extensive cultivation of sugarcane. The compost improves soil tilth and water holding capacity thereby reducing irrigation needs. It is reported to increase crop yields by 15 to 20 percent over a period of 3 years.

Compost reduces chemical fertilizer requirements by trapping and holding minerals from fertilizers which otherwise get leached out of the soil. Farmers using the compost have indicated that application of compost reduces chemical fertilizer needs by 10 to 30 percent without loss in productivity. It is also rich in natural plant growth stimulants and enriched with beneficial micro flora. The pressmud based compost is consistent in quality and completely free from pests, pathogens, nematodes and weed seeds.

Table 4. Characteristics of Pressmud Based Compost.

Parameters	Values
Moisture	30 - 35%
Total organic matter	40- 45%
Organic carbon	23 - 26%
Total nitrogen	1.7 - 2.5%
Phosphorus	1.0 - 1.5%
Potassium	3.0 - 4.0%
Calcium (as Ca)	2.0 - 4.0%
Magnesium (as Mg)	1.5 - 2.0%
Sulphur (as SO4)	2.0 - 3.0%
Iron (as Fe)	0.1 - 0.5%
Zinc	50 - 100 mg/kg
Manganese	150 - 500 mg/kg
Copper	30 - 50 mg/kg
C:N ratio	Between 10:1 & 15:1
pH	7.0 - 8.0

CONCLUSION

After the Green Revolution, Indian farmers started using large quantities of chemical fertilizers, pesticides, herbicides and fungicides despite warnings from agricultural scientists about long term effects on soils and the environment. Because of this continued practice, the sustainability of agricultural production has been jeopardized by the harm inflicted upon the physical, chemical and biological fertility of the soil. In this scenario, it is imperative to add adequate quantity of organic matter to soils in order to increase soil fertility and achieve sustainability in crop production.

Sustainable agriculture is based on the continued recycling of soil nutrients. Sugar industry pressmud and distillery spentwash, which were once considered as nuisance can now be used as a means to support sustainable agriculture. The successful implementation of solid-state aerobic composting technology for the conversion of pressmud and distillery spentwash into a value-added ecofriendly compost has shown that this option is a commercially viable, environmentally acceptable, and practically enforceable option for the integrated sugar distillery complexes.

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ENERGY FROM BIOMASS

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Life is the manifestation of energy. Life exists only when energy exists. The usage of energy is the index of prosperity. More the use of energy, higher is the production in industry and in agriculture. The man realized the importance of nature and sun when he understood that his very survival is due to the energy he is receiving from them and thus, in awe, he started worshipping the sun and nature as his protector. Two sources primarily provided him energy - the sun and biomass.

Every year the plants store about 10 times the energy the world now consumes annually. At any one time, biomass stores as much energy as all the proven reserves of fossil energy sources - coal, oil and gas put together. Yet even today, only one-seventh of worlds total energy comes from biomass. A large and renewable resource is thus left largely untapped (Ghose et, al 1981). Biomass has provided energy since millennia. Till the middle of last century, biomass dominated the global energy consumption. In this century, the rapid increase in fossil fuel use contributed to the decline in the share of biomass in total energy. To quote, until the middle of nineteenth century, USA derived 90% of energy from wood while presently it derives only 3.2 percent of the total energy. Biomass still remains an important energy source and contributes 14% of the world energy and 38% of energy in developing countries (Woods and Hall, 1994). Table 1

Table 1. Growth in primary commercial energy consumption of selected countries, 1993-2002.

Country/region	Growth (%)
Bangladesh	80.8
China	31.6
India	46.2
Thailand	69.7
Developing Asia Pacific	37.3
Total Africa	28.3
Total South and Central America	21.6
Japan	9.2
UK	1.7
US	12.6
World	14.2

Ministries of Petroleum, Power and Coal along with data from MNES shows the global biomass energy consumption and growth during past two decades while Table 2 provides the yearwise primary energy consumption pattern in India in last decade (Upadhyay 2005).

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Table 2 : Primary Energy Consumption in India

Sr. No.	Source	Unit	90-91	95-96	98-99	99-00	00-01	01-02	02-03
1.	Petro Products	MT	57.75	77.91	94.26	102.63	106.97	110.96	111.07
2.	Natural Gas	BCM	12.77	20.93	25.71	26.89	27.86	28.04	29.97
3.	Coal	MT	211.73	270.13	292.27	299.97	309.63	322.61	336.52
4.	Lignite	MT	13.77	22.14	23.42	22.12	22.95	24.81	26.10
5.	Hydro Electricity	Bill units	73.9	72.6	82.6	80.5	74.3	73.9	63.8
6.	Nuclear Electricity	Bill units	6.1	7.9	12.0	13.3	16.9	19.3	19.2
7.	Renewable Energy based Electricity	Bill units							10*
8.	Non-commercial								
	- Firewood	MT	-	-	-	-	-	-	223
	- Animal Waste								130

MT : Million Tonnes BCM : Billion Cubic Metres

* estimated from the installed capacities of SHP, wind and biomass

Biomass, a renewable source of energy, has a tremendous potential to minimize the gap between supply and demand of energy. Biomass resources are potentially the worlds largest and most sustainable energy source- a renewable resource comprising of 220 billion oven dry tonnes of annual primary production (Hall and Rao, 1990).Biomass energy offers a number of advantages to the people as well as the countries using it. Its renewable nature, wide availability, carbon neutrality, employment generation potential, etc. are behind the recent resurgence in interest in biomass energy all over the world.

India, the world's second most populous nation, has seen its population grow from 300 million in 1947 to more than one billion today with approximately a quarter living in urban areas. India is the sixth largest energy consumer of the world. India is also the worlds third largest producer of coal and relies on coal for more than half of its total energy needs. Oil accounts for about 30% of India's total energy consumption. Future oil consumption is expected to grow rapidly from 1.9 barrel/day in 2001 to 3.4 million barrels/day by 2010. Currently, renewable sources (excluding large hydro) merely accounts for about 3% of the total power generation in the country (Bhattacharya, 2001).

The alternate source of energy that mankind must find to solve his present fuel demand problems should have following attributes (Jain, 1991).

- Given the increasingly large gaps between demand and supply for all forms of energy (i.e. electricity, fuel, thermal energy etc.), the new source should preferably be capable of providing all the energy i.e. electricity, fuel, thermal energy etc.
- The source should be available to provide energy/power at both the small scale/ localized/decentralized level as also at large scale/centralized level (grid-connected power generation being an example).

- The source should be capable of providing energy/power "on demand".
- If the source is to start its contribution almost immediately, the gestation periods should be short.
- If the source is to meet even the peak demand (a major constraint in terms of the current supply situation), it should have a very short start-up time.
- Given the tremendous constraints on available financial resources, it should not be very capital intensive.
- As energy/power costs are already seen as being high, cost of producing energy/power from the new source should not be exorbitant.
- Given the already precarious environmental and social balances, its widespread use should be environmentally benign and socially desirable.
- Given the increasing concern about global climate (global warming in particular and acid rain etc. in general), its deployment should not result in net CO_2 addition and/or sulphur oxides emission.

It is obvious that any new source that meets a large number of these attributes can be expected to contribute extensively to the national energy scenario. It is indeed amazing to note that biomass as an energy source meets almost all the above attributes, as briefly elaborated below:

- Even with readily available conversion technologies, biomass can indeed provide all forms of energy (i.e. electricity, fuel, heat etc.) in an effective and efficient manner.
- By appropriate choice of conversion technologies/devices, it is again possible to meet either small scale, decentralised energy/power needs or large scale, centralised needs (like grid-connected power generation). Of course, for the later option, biomass availability has to be ensured.
- Because of the natural and cheap storage of energy in the form of biomass itself, requisite energy/power can indeed be made available "on demand". In many ways, biomass as an energy source which can be compared with coal/petroleum except for its relatively low energy density.
- Typical biomass conversion technologies and associated hardware have an implementation timescale of a month to a couple of years (at most) and such a short gestation period can indeed allow it to start contributing right away, depending on the resources availability.
- Meeting peak demand requires a hardware/device which can be started and stopped almost instantaneously. Some of the biomass based technologies (gasification, for example) can have a very short start up time which make such source-device combination ideal for meeting peak demands.
- Inspite of the various strengths listed above (and others mentioned below), the capital intensity of a number of biomass conversion technologies is quite reasonable and even lower than most of the conventional energy/power production technologies. For example, capital investments for power generation even with currently available

technologies are only of the order of Rs. 10,000/- per kW of the installed capacity. For the sake of comparison, even a large sized thermal power plant requires capital investment of at-least Rs. 35,000/- per kW (not counting additional investments of coal mining, railway and other infrastructural expenditure).

- Given the low capital intensity, cost of energy/power production is largely dictated by the cost of biomass and, in most instances, unit costs of producing energy/power are at least comparable to conventional costs, if not lower.

- Appropriate coupling of energy production programme with biomass production programme is probably one of the few potential schemes with tremendous environmental and social benefits. Such close coupling could indeed provide the requisite economic reason for afforestation activities to be commercial and successful. Positive environmental impacts of large scale afforstation are already very well known and very large scale employment generation for relatively weaker sections of the society can also be ensured through such production porgrammes.

- Once biomass production and its conversion for energy purposes are closely coupled, there is absolutely no net CO_2 release and given the very nature of afforestation and plantations, the net impact on CO_2 can be easily expected to be in terms of a slight decrease. This aspect is also very well recognized the world over and this has indeed been recommended as one of the few options available to mankind for arresting global warming. Of course, biomass has almost negligible sulphur content and hence problems of acid rain etc. can also be counteracted. Biomass is an important source of energy, accounting for a quarter of the national energy consumption. Biomass energy dominates the rural energy consumption pattern in India, accounting for nearly 75% of the energy consumed. Large increase in commercial energy use at national level has not influenced bio-energy use in the rural areas.

As a renewable fuel, biomass is used in nearly every corner of the developing world as a source of heat, particularly in the domestic sector. Unlike other renewables, biomass is a versatile source of energy, which can be converted to 'modern' forms such as liquid and gaseous fuels, electricity, and process heat. Bio-energy also permits operation at varying scales. For example, small-scale (5-10 kW), medium-scale (1-10 MW) and large-scale (about 50 MW) electricity generation systems or biogas plants of a few cubic metres (Indian and Chinese family plants for cooking) to several thousand cubic metres (Danish systems for heat and electricity).

Impressive goals for exploitation of biomass have been set in major countries for the coming 20-50 years. Dedicated energy plantation is being adopted by many countries to minimize the use of ever depleting sources of fossil fuels. Brazil has put 3 million ha of eucalyptus plantation for making charcoal. China- as a plantation program for 13.5 million ha of fuel wood by 2010; Sweden, where about 16000 ha of willow plantation used for generation of heat and power; USA where some 50,000 ha of agricultural land has been converted to woody plantation, possibly increasing to as much as 4 million ha by 2020. For India, biomass has always been relevant. Unlike petroleum and coal in which the country is not very well endowed, its biomass resource is abundant and hence looks as a likely candidate for bridging the gap between demand and supply of energy. To bridge up this gap, the country has to go for intensive, dedicated efforts for production and effective and efficient use of biomass.

Biomass Production

There are three main categories of biomass in India, which can be utilized for power generation. These are; materials derived from agriculture and agro industries; from forests; and from roadside and wasteland growths. The largest quantum of all these is the biomass from agriculture, which comprises primarily of various crop residues. A list of possible biomass materials available for power production in the country is given in Table 3.

Table 3: Biomass Materials which could be used for Power Production

Agricultural Residues	Agro-Industrial Residues	Forest and other Residue
Paddy Straw	Rice Husk	Deadwood from existingforests
Pearl millet Stalks	Bagasse	Wood from specially grown plantations
Sorghum Stalks	De-oiled cakes	
Maize Stalks	Groundnut shells	Saw mill wastes
Millet Straws	Castor/oilseed shells	Pulp wood wastes
Sugarcane trash	Tea/coffee wastes	Road side bushes
Coconut shells, fibre & pith	Cotton ginning waste	Wood from wastelands
Banana plant waste	Cashew nut shell	
Cotton Stalk	Coconut shell	
Pulses-straw & stalks	Coconut fibre	
Oilseed straw	Coconut pith	
Tobacco straw		
Jute & Mesta Sticks		
Castor Stalks Mustard stalks		

Source: Upadhyay *et.al* (2005)

It is well known that biomass is a poorly documented energy source. The inability to fully address the indigenous biomass resource capability and its likely contribution to energy and development is still a serious constraint to the full realization of this energy potential. As per one estimate, the biomass consumption in rural areas of developing countries (including all types of biomass and end uses) is about 1 tonne (15% moisture, 15 GJ/t) per person per year and about 0.5 tonnes in semi-urban and urban areas. As per one estimate, 1000 million tonnes (MT) of biomass is annually generated in India (Table 4).

The biomass can be used for deriving useful energy for household, agriculture, transport and industry through several traditional, modified and advanced technologies under 'Thermo-chemical conversion' and 'Biological conversion'. Thermo-chemical conversion includes technologies like pyrolysis, liquefaction, gasification and combustion. Biological conversion includes anaerobic digestion and fermentation.

Thermo-chemical Conversion of Biomass

The thermo-chemical conversion of biomass can be classified into four processes namely - Combustion, Gasification, Liquefaction and Pyrolysis. Each method gives different range of products, employs different equipment configurations and operates in different modes. Different conversion technologies along with their primary product and applications are presented in Table 5 and Fig.1.

Table 4: Aggregate Biomass Generation in India.

Source of Biomass	Estimate of the Quantity generated, in MT
Agriculture/agro-industrial, excluding sugarcane derived materials	439.43
Sugarcane based materials including tops and trash	84.01
Roadside growths	10.74
Forest residues	157.18
Growths on Wastelands	27.12
Agro forestry waste	9.06
Dung live stock	267.76
Poultry droppings	4.86
Total	1000.17

Source: Upadhyay *et al.* (2005)

Table 5: Thermo-chemical conversion technologies, primary product and applications.

Technology	Primary product	Application
Pyrolysis	Liquid	Liquid fuel substitution, chemicals
Fast or flash pyrolysis	Charcoal	Solid fuel or shurry fuel
Carbonization	Gas	Fuel Gas
Slow pyrolysis	Liquid tar	Liquid fuel substitution, chemicals
Liquefaction	Solid char	Solid fuel or shurry fuel
Gasification	Liquid	Oil or liquid fuel substitution
Combustion	Gas	Synthesis gas or fuel gas
	Heat	Heating

Source: Agblevor *et al.* (1994)

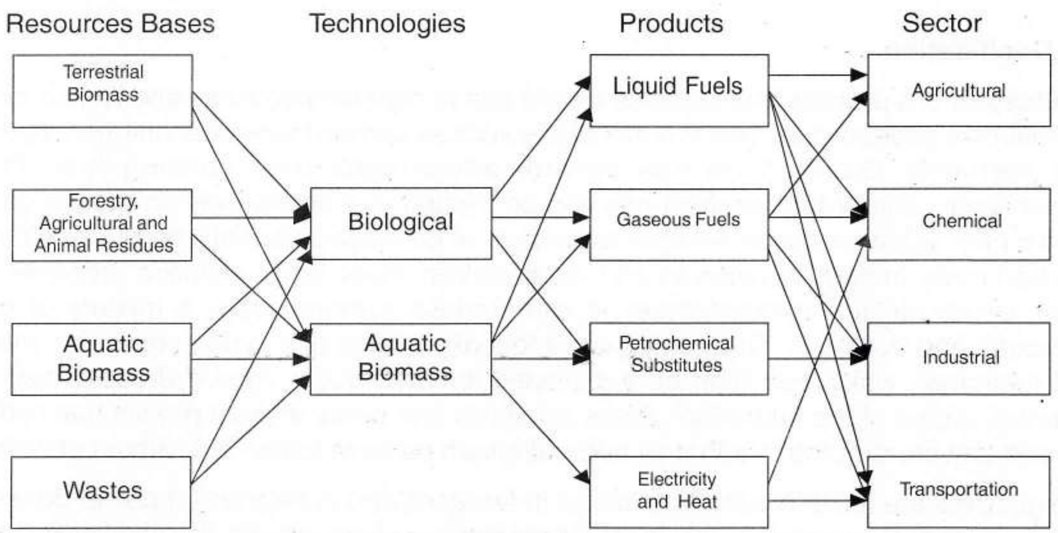

Fig. 1 : Thermo chemical processing of biomass and their products

(i) Combustion

The simplest, cheapest and most common method of obtaining energy from biomass is direct combustion. Any organic material with a water content low enough to allow for sustained combustion can be burned to produce energy. The heat of combustion can be used to provide space or process heat, water heating or through the use of steam turbine, electricity. In the developing world, many types of biomass such as dung and agricultural wastes are burned for cooking and heating. Wood was once our main fuel. We burnt it to cook our food. It is still our domestic fuel in villages. However burning wood, animal dung and other biomass is inefficient way of getting heat for cooking. An open fire place lets large amount of heat to escape while a significant proportion of the fuel may not even get burnt. Up-to three quarters of the energy in biomass fuels may be contained in volatile matter - compounds released as the fuel heats up. If the fireplace is inefficient, much of this volatile matter simply go up in smoke without burning and pollute the atmosphere.

This is a process in which the biomass is degraded at higher temperatures to char and volatiles, which in turn are oxidised with the excess oxygen provided. A large amount of heat of reaction is released along with formation of carbon dioxide and water as gaseous emit ants. With the present state of various technologies and 'with the niche scale of biomass power generation being 5-20 MW, biomass combustion based steam power plants are still the most economical and popular route (Ganesh et. al., 2001).

Solid wastes are also burnt to provide heat for steam generation to run turbines and generate electricity as shown through flow diagram at Fig. 2. Table 6 gives a comparison of various conversion routes for generation of electricity from biomass through combustion.

Burn fuel → Heat water to generate steam → Steam runs turbines → Turbines runs generators → Electricity is produced

Fig.2 : Flow diagram of electricity production by buring (combustion) of biomass.

(ii) Gasification

Gasification is a process that exposes a solid fuel to high temperatures and limited oxygen, to produce a gaseous fuel. This is a mix of gas such as carbon monoxide, nitrogen, hydrogen and methane. Gasification has several advantages over burning fuel. One is convenience- one of the resultant gas can be treated in a similar way as natural gas and used for the same purposes. Another advantage of gasification is that it produces a fuel that has had many impurities removed and will therefore cause fewer pollution problems when burnt. Under suitable circumstances, it can produce synthesis gas, a mixture of carbon monoxide and hydrogen. This can be used to make almost any hydrocarbon (eg. methane and methanol) which can then be substituted for fossil fuels. Also hydrogen, itself is a potential source of the future fuel. Some scientists and policy makers predict that hydrogen will one day perform the role that oil and petroleum perform today- but without pollution.

The gasifiers are used to substitute fuel oil in furnaces and in engines for power generation. With the diesel prices increasing steeply in the last two years in India, the gasification market has seen a boom. The development and subsequent availability of Spark Ignition Producer

Gas Engine (SIPGE) will further boost the use of gasification for power generation - within the economic scale of operation with respect to the biomass availability, transportability and storability.

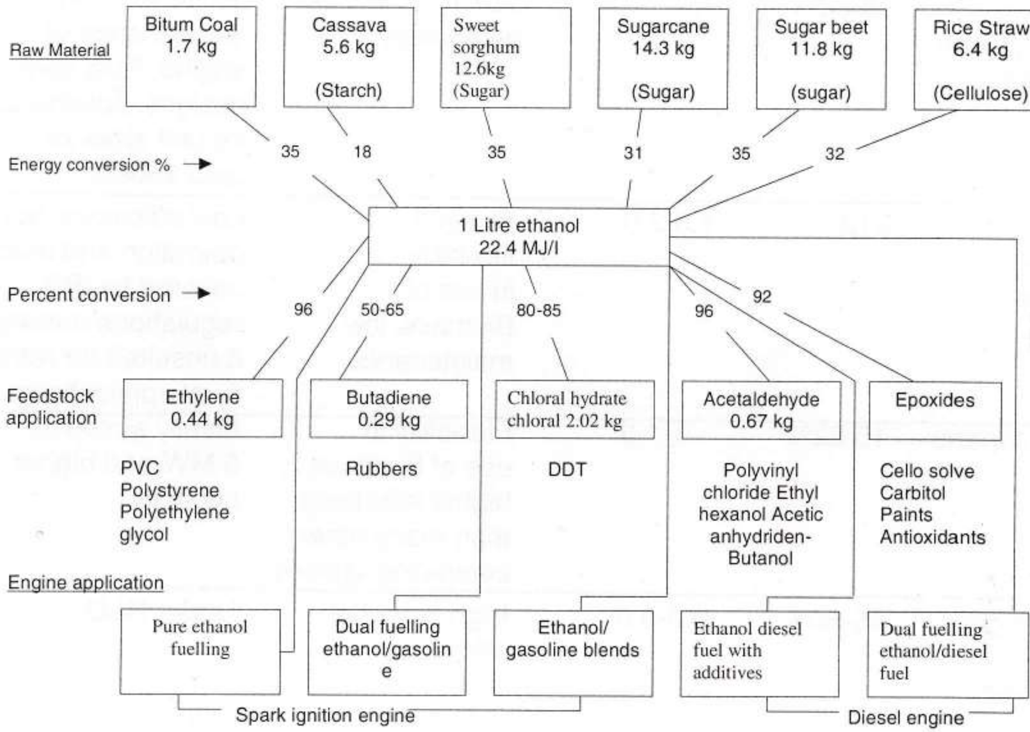

Fig. 3: Sources for Ethanol Production and routes for Ethanol application

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Fig. 3 : Sources for Ethanol Production and routes for Ethanol application

(iii) Pyrolysis

Pyrolysis is an old technology with a new leases of life. In its simplest form, it involves heating the biomass to drive off the volatile matter, leaving behind the black residue known as charcoal. This has double the energy density of the original material. This means that charcoal which is half the weight of the original biomass contain the same amount of energy - making the fuel more transportable. The charcoal also burns at a much higher temperature than the original biomass, making it more useful for manufacturing processes. More sophisticated pyrolysis techniques have been developed recently to collect the volatiles that are otherwise lost to the system. The collected volatiles produces a gas, rich in hydrogen (a potential fuel) and carbon monoxide. These compounds, if desired, can be synthesized into methane, methanol and other hydrocarbons. 'Flash' pyrolysis can be used to produce bio-crude-a combustible fuel.

Table 6. Comparison of Options for Conversion of Biomass to Electricity

Option	Efficiency	Relative Costs/kW	Advantages	Limitations
Gasifier-IC Engine (100% gas based)	15-22%	1.0	Low cost, simple technology	Likely increased maintenance of engine, Fuel specific designs, suitable only for unit sizes of upto 250kW.
Steam Engine-Rankine Cycle	<10	1.5-2.0	Rugged, flexibility in use of Biomass, low maintenance	Low efficiency, boiler operation and design covered by IBR regulations making it unsuited for remote rural applications.
Steam turbine	15-22%	1.1-1.3	Flexibility in use of Biomass, higher efficiency than many other competing options	Ideally suited for 5 MW and higher capacity
Gasifier-gas turbine combined cycle	45-50%	2.0-3.0	High potential efficiency	Under R&D
Sterling engine	20-30%	1.5-2.0	Flexibility in use of Biomass, high conversion efficiency	Under R&D

Source: Upadhyay *et al.* (2005)

(iv) Liquefaction

Another technique that uses high temperatures to convert biomass is liquefaction. It can be both a direct and indirect process of thermo chemical conversion. The former is usually catalytic, the feed being first converted into a gaseous intermediate from which liquid fuels are then synthesized. In one of the direct liquefaction processes, the biomass slurry containing the catalyst is fed to a high pressure (but not more than 280 kg. per sq (cm) and medium temperature (340^{o}C) reactor where liquefaction reaction take place in a reducing gas atmosphere (with carbon monoxide and/or hydrogen also being fed to the reactor). A series of complex reactions occur simultaneously - pyrolysis, gasification and volatilization. Hydro gasification by pyrolysis in the presence of hydrogen produces mainly methane and water. The gas, containing the combustibles, is removed and can be used as heat source to pre-dry the wood feedstock. The liquid-solid mixture is then separated by distillation. The bottoms containing residual solids can be recycled together with a portion of the oil which is not removed as product. After the oil product is separated, vacuum distillation would allow a product as desired. The product composition will, of course, depend on the biomass feed.

In the indirect liquefaction process, there are two stages. In the first, the biomass is gasified to an intermediate species which in the second is converted to methanol, gasoline or polymerized liquid hydrocarbons. The intermediate mixture could be synthesis gas (carbon monoxide and hydrogen), light olefins (ethylene and propylene), etc. Methanol synthesis has been in wide commercial production for many years. Most methanol production to day is based on natural gas as the feed source. This generally requires a higher hydrogen to carbon monoxide ration than a biomass gasification unit.

Only methanol is being considered as a prospective alcohol to be derived from biomass by thermo chemical means. At present, methanol from wood would be more expensive than that from coal, partly due to the smaller scale of biomass units. Nonetheless, there are opportunities to decrease the costs. Clustering the gasification units near biomass sources and transferring the gas to a central methanol unit could greatly reduce cost. The Mobil Corporation has also developed a process for converting methanol and other aggregates into high octane gasoline:

$$n\,(CH_3\,OH) \xrightarrow[\text{catalyst}]{} (-CH_2-)\,n + nH_2O$$

With methanol feedstock a zeolite catalyst allows a yield of about 85 percent of hydrocarbons (gasoline) containing virtually no component heavier than C_{10}.

Biological Conversion

In contrast to thermo-chemical conversion processes, biological conversion processes are less energy intensive and take place at near atmospheric pressure at low temperatures (30 to 80^0 C). Biological conversion entails an energy-yielding enzymatic breakdown of biomass by selected species of microorganisms. The product can be gaseous and liquid fuels, food, animal feed, fertilisers and other chemicals.

(i) Anaerobic digestion/ Biomethanation

Anaerobic digestion is an important biological conversion process yielding methane. It converts biomass in the absence of oxygen (by anaerobic digestion) to methane, popularly known as biogas, leaving a stabilised residue which makes an excellent organic manure. Traditionally in use for about a century, anaerobic digestion is a very complex process which only recently is beginning to be understood. Basically anaerobic digestion consists of three phases: the enzymatic hydrolysis of biomass, organic acid formation and methane generation. The total process requires a symbiosis of acid-forming and methane-forming microorganisms. The reactions of the two groups must occur simultaneously; if these become unbalanced, the digestion process fails.

Methane production here is further influenced by three main factors- the nutrient components of the biomass substrate, the temperature and the pH. Carbon and nitrogen are essential for bacterial metabolism, so the suitability of the materials for methane production is based on their carbon-nitrogen ratio, which should be around 30 for optimum production.

There are two types of methane forming bacteria, requiring different temperatures for optimum growth. The mesophilic organisms grow best around 35^0 C, while the thermophilic organisms find an optimum temperature around 55^0 C. Methane production decreases rather drastically as the temperature drops below optimum level so that temperature control is a must for good yield. As a thumb rule, methane production drops by 50 per cent for every 11^0C decrease in temperature. A pH range of 6.7 to 7.6 is normally adequate.

Theoretically, in biogas plants, the fermentation of cellulose (the chief constituent of plant tissue), should give off equal amounts of methane and carbon dioxide, but actually, part of the carbon dioxide produced remains fixed on organic or mineral bases or remains dissolved in the water. Hence, biogas produced from farm residues consists of 55 to 65 per cent methane and 35 to 45 per cent carbon dioxide along with 0.3 per cent nitrogen, up to 1 per cent hydrogen, up to 1 per cent oxygen and traces of hydrogen sulphide. The biogas produced in a well functioning digester may have a heat value of 22.92 mega joules per cubic metre (compare the value for natural gas 39.58 mega joules per cubic metre). The energy value of the biogas can be increased by removing carbon dioxide by passing the gas through water. The gas may be used to provide heat in stoves or space heaters or for work in internal combustion engines.

If biogas is to be used in engines, hydrogen sulphide, the most corrosive component present in biogas of any origin, must normally be removed by the sponge iron process. The use of biogas as a diesel substitute has been successful by mixing 85 per cent biogas with 15 per cent diesel in engines to run tractors and other agricultural implements; this system has become popular among farmers.

When cow-dung is used in biogas plants, an output of 0.063 cubic metre of biogas per kg of cowdung digested is possible. This is equivalent to 120 cubic metres of methane per tonne of volatile solids digested. Better outputs are reported from specially grown plants like water hyacinth. However for practical reasons the methane yields are normally within 100 to 140 cubic metres per tonne of volatile solids digested- an efficiency of about 20 to 25 per cent.

Besides animal dung, current research efforts are also being concentrated on other biomass materials such as rice husk, straws, aquatic plants etc. either alone or in mixtures. Digested biomass, an excellent manure and a good soil conditioner, contains 2 per cent nitrogen, 1 per cent phosphorus, 0.7 per cent potash and 50 to 70 per cent of organic humus.

Digestion of mixed residues (gobar, water hyacinth, algae, etc) gives greater overall efficiently, both in terms of energy recovery as well as the fertiliser value of the digested residue. A mixed residue resulted in a 2.3-fold increase in methane production as compared to cowdung alone. The separation of acidogenic and methanogenic phases and the application of multi-reactor system have been demonstrated to provide even greater overall efficiency. A methane yield of 230 cubic metres per tonne of volatile solids digested, has been achieved in the latter system as compared to 159 cubic metres per tonne of volatile solids digested mostly reported.

(ii) Fermentation

The process of alcohol production by fermentation using the enzymes of yeast is as old as human civilization. Alcohol was the fuel used when IC engine was invented. It was soon replaced by petroleum fuel which was available in abundence at much lower price. Gasohol, which is a blend of gasoline and alcohol, has been found to be a much cleaner fuel than gasoline and has been used extensively in automobiles without any modification in the combustion system of SI engines. It has higher octane value and antiknock properties than gasoline and bums slowly, coolly and resulting in reduced emissions. Brazil is pioneer in blending up to 24% ethanol with gasoline. Government of India has also implemented blending of 5% of ethanol with petrol used as automobile fuel. The world ethanol production in 2001 was 31 Gl. The major producers of ethanol are Brazil and the US which account for about 62% of the world production. The major feedstock for ethanol in Brazil is sugarcane while com grain is the main feedstock for ethanol in the US. Regardless of the raw materials being used to produce alcohol, there are invariably four major steps involved:

(i) Pretreatment: Raw materials rich in carbohydrates must in some way be converted into fermentable sugars.

(ii) Fermentation: The fermentable sugar is utilized by yeast (or possibly some other micro-organism) to produce alcohol and carbon dioxide.

(iii) Concentration: The alcohol produced during fermentation is concentrated by distillation to 100% alcohol.

(iv) By-product formation: The spent wash left, after the alcohol has been removed, is processed into a by-product.

While it is true that any biomass containing carbohydrates can be considered as feedstock for alcohol production, the yield of alcohol per tonne of individual feedstock varies considerably. Feedstock for alcohol production can be classified into 3 main categories:

(i) Those containing starch

(ii) Those containing sugar

(iii) Those containing cellulose

The technology for ethanol production from starchy biomass such as corn grain is being widely practiced in US. Like-wise technology for ethanol production from sugarcane is also available and is widely used for production of fuel ethanol in Brazil. These technologies can be adopted easily. But sufficient land will have to be earmarked for this purpose. Fig.3 shows information on ethanol yield and conversion efficiencies, and routes for ethanol applications.

Decentralised Energy Generation Strategy

From above discussions, it becomes clear that biomass is a potential future sustainable source of energy with CO_2 neutral and environment friendly. As it is distributed widely, decentralized system for generation of energy from biomass can be the viable solution to meet the future demands of country and the world. Present Development Model of the country is based on 50-100 year old model of western countries which include centralized energy production, development of mega. cities at the expense of rural areas and the unsustainable husbanding of land. This development model has led to high levels of unemployment and poor quality of life in rural India and large scale exodus of population in big cities. This exodus is the result of lack of sustainable agriculture in rural areas (Rajvanshi 2002).

Agriculture is mostly dependent on energy. Lack of energy is therefore the single most important reason for decline of agriculture based activity and hence the economic activities in rural areas. A sustainable food and energy strategy for rural areas will therefore create new economic activities and can stop the desperate exodus to cities.

In India, about 75% of the population lives in rural and semi urban areas. It is estimated that for the next 50 years or so the major part of population in India and other developing countries will still be rural-based. Hence rather than pumping in huge resources in urban areas where the quality of life is becoming worse by continuing on the present path, it is much better to improve the quality of life in rural areas via an alternative model based upon sustainable growth and renewable energy. The government claims that an estimated 310,000 of India`s half-a-million villages have electricity. In reality, this is usually unreliable, irregular and of poor quality. About 80,000 villages have no power, as it is neither feasible nor economical to connect them to conventional electricity. For the millions who have never experienced the magic of power, it also means that there are no small industries in these areas, given the prohibitive costs of diesel generators.

Sharan and Khosla (1996) have suggested the concepts of independent rural energy/power as an instrument for sustainable rural development. Authors suggest the need for creation of Independent Rural Power Producers (IRPP) to meet the power needs of small consumers in small towns and villages. An IRPP should use energy resources that are renewable and locally available and operate on a commercially viable basis. While promoting sustainable development at the community level, it will also eliminate net CO_2 emissions and thus automatically help reduce the risk of global climate change.

On this line, several NGOs and government aided centres and institutions have come up to work on generation of electricity through small units. Nimbkar Agricultural Research Institute (NARI), Phaltan (MS) has developed several technologies on commercial scale like Biomass Gasifiers and Plants for producing ethanol from sweet sorghum. The NARI provides a Thermal Gasifier of 800 kW capacity at the cost of Rs. 13 lakhs. Only two operators per shift are required for running this gasifier. Here 20-24% of the fuel is converted into char which is a value added by-product.

As per news in 'Business in Development', September 16, 2004, Decentralized Energy Systems (India) or DESI Power had set up a power plant using agro-waste in Baharbari village in Bihar in 2001. It is a backward village situated in north-eastern Bihar connected with bad roads and with closest communication network which is a 2 hour walk and diesel pumps on hire are available after a 56 km journey. DESI power installed a 50 kW Power Station in 2001 with energy produced from rice briquettes. In the beginning, farmers had no idea about the importance of electricity. However, today a cooperative oversees the growth of micro scale industries in this village which are alive with noisy electric pumps, battery charging stations, rice and flour mills and a briquetting press. The farmers now pay Rs. 35 to 49/- an hour for pumping water in their fields. As per the report, the power generated is cheaper than that from diesel generation. It is more reliable and cleaner than fossil fuels fired plants. It has promoted sustainable local livelihoods by creating jobs to operate the power plant and growing village industries. DESI Power builds and eventually transfers the plants to local ownership. As per news report, it has built nine plants in the states of Karnataka, Tamil Nadu in the south, Orisssa in the east, Bihar in north-east and Madhya Pradesh in central

India, as well as one in Kenya. Such changes are a new hope for the country which has sufficient biomass well distributed all over the region and is available round the year.

The Ministry of Non-conventional Energy Sources (MNES) has accorded high priority to harness of energy from biomass through gasifiers. The MNES has embarked on a project to provide power to 15 villages in Karnataka by the utilization of biomass. The project aims at sustainable transformation of energy in rural areas of Karnataka and on completion would provide power to 15 villages in the Tumkur district of the state. The energy would be produced through biomass gasifiers for stand-alone applications and then would be supplied to the villages. The stand-alone gasifiers would be located in every village and would be within the capacity of 60 to 100 kW (Ref:The Business Standard, 25 February 2005). Biomass for power generation has been recognized as an important component of the renewable energy programme in India and this is reflected in the priority attached to it by the MNES. Biomass collection logistics and competing uses of biomass are the most serious constraints in the widespread utilization of this resource for power generation. Nevertheless, there are niches with substantial potential for use of biomass for power generation, e.g. bagasse cogeneration in sugar mills, biomass waste from agricultural operations or agro-industries in concentrated geographical pockets. Potential for biomass utilization, in general, and biomass gasification, in particular, indicates that, by taking into account the demand for fodder etc., the biomass available in the country (excluding animal residues) can optimistically support electrical power plants aggregating to a total of 17000MW.

Ravindranath *et.al* (2004) made a case study on the performance and impact of a decentralized 20 kW biomass gasifier-engine generator based power generation system in unelectrified Hosahalli village of Karnataka. This system is providing electricity successfully (population 218 in 2003) for lighting, piped drinking water, running irrigation pumps and flour mills for last 14 years (1988-2004) and meeting all electricity needs of the village for over 85% of the days. The fuel, operation and maintenance cost ranged from Rs.5.85/kWh at a load of 5 kWh to Rs.3.34/kWh at aload of 20 kW.

In the Betul district of Madhya Pradesh, an energy production unit comprised of two 10-kW biomass gasifiers and engine-gensets has been recently installed to provide electricity to meet the total energy requirements of 55 tribal households in an adivasi (original inhabitants) village. This project is said to be the first test project of Village Energy Security using locally available biomass material. Plantations of fast-growing species have been completed in 10 hectares of land around the village to ensure sustained supply of wood for the gasifiers. An Expeller unit will be installed to produce bio-oil from the oilseeds of the Jatropha plantation, which will be used for running pumpsets. Improved chulhas (cookstoves) have been constructed in every house to conserve firewood while biogas plants are being built to provide cooking energy to the households. Lights for each household, school, engine room and streets have been provided. A flourmill is being energized and a water pump and milk-chilling unit are also proposed. The villagers welcome development of their village, anticipate income generation and expect improvement in their quality of life.

The Haryana cabinet has approved setting up of two biomass projects with generation capacity of 17.55MW at Ambala and Karnal with a cost of Rs. 52.60 crore for generation of power through non-conventional energy sources. The 12 MW power plant to be set up at Ambala at a cost of Rs. 37.10 crore would generate power through rice straw, rice husk, wheat straw, bagasse and cotton stalks. The second project of 5.5 MW being set up at Karnal at a cost of Rs. 15.50 crore would generate power through cotton stalks, wheat straw, rice straw and rice husk. These units would be established with indigenously available technology for producing power by the use of steam turbo generator of extraction-cum-condensing type (The observer of Business and Politics, June 26, 2000).

In July 2004, the federal Ministry of Non-Conventional Energy Sources announced a new project that would use biomass or organic waste to meet all the energy needs of about 25,000 remote villages unreachable by the national power grid.

Conclusions

Biomass, currently supplies 14% of the worlds energy needs while it has a potential to supply 100 % (Baird,1991). There has been a growing interest in modern biomass technologies around the world in recent years. In most developing countries, biomass energy consumption is rising, although the share of traditional fuels in total national energy use has been falling (Bhattacharya, 2004).

The current advantage that fossil fuels, particularly coal, have over biomass in terms of market price would substantially diminish if the environmental costs were factored into the pricing of fuels. Given that one of the main reasons for the current level of interest in renewable energy is concern about the environmental impact of large-scale fossil fuel use, it is not reasonable to exclude such concern from energy pricing, as is largely the case today. Most present day production and use of biomass for energy is carried out in a very unsustainable manner with great many negative environmental consequence. If biomass is to supply a greater proportion of the worlds energy needs in the future, the challenge will be to produce biomass sustainably and use it without harming the natural environment. With fair pricing for energy, biomass-based generation would become viable in a wide range of situations, and the pace of commercialization for the technology would accelerate. In the near future, our concern over climate change and volatility in the world oil market will improve the prospects for renewable energy technologies.

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DAIRY AND POULTRY FARMING WASTE MANAGEMENT

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Wastes are generated primarily by the agricultural, industrial and municipal segments of the population, including wholesalers and consumers. Management of such waste needs urgent attention because the reduction of waste can reduce the pollution and also recycling and conversion of Agricultural waste into livestock feed will ameliorate the present situation of livestock feed scarcity.

The increasing costs and pressures concerned with waste disposal stress the need for a reappraisal of the utilization of waste, either directly (as a feed ingredient, such as citrus pulp or feather meal) or indirectly (upgrading by micro-organisms such as algae, larvae house-fly, earthworm etc.) for livestock and poultry feeding. Present-day investigations therefore must include studies on the management of waste, its technology and subsequent feeding value for livestock.

Agricultural waste originates from the primary agricultural production (plant products such as straw, culls, leaves, press cakes), from intensive farm production (animal and poultry by-products - as manure) and from livestock processing plants (by-products of slaughtered animals and tannery). All these materials merit consideration to be converted to animal and vegetable feedstuff which is fed to poultry and Livestock for production of animal protein viz. eggs, milk, meat, etc. for human consumption. The processed animal waste can be considered as useful new feedstuff to be included in the category of agro-industrial by-products. Alternatives are its use as fuel from manure (methane), as fertilizer, or its use as a substrate for microbial fermentation processes (Boushy and Van der Poel 2000).

Animal waste disposal:

Animal wastes have been traditionally disposed by spreading them on the land. However, since the advent of chemical fertilizers, there has been a significant decline in the use of organic fertilizers, mainly owing to the costs of transport compared with that of chemical fertilizers. However, other modes of conversion of wastes are possible such as the conversion into feed by ensilation, dehydration, chemical treatment or fermentation to yield protein biomass. The estimated recovery from these conversion methods varies widely but the value of animal wastes as a feed ingredient appears to be far superior to their other uses with operating costs for conversion being low. The method of waste disposal include waste treatment or waste utilization and, in general, conversion for use directly into food, feed or upgrading by micro-organisms.

Slaughter House waste:

Slaughtery by-products can be divided into primary by-products and secondary ones. The primary products may include hides and skins, feathers, bones and also hatchery by-products such as infertile eggs and egg shells; the secondary by-products includes a

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wide range of products manufactured from the primary by-products. The secondary products include blood meal, blood albumen, egg albumen etc.

Benefits derived from the use of feed from waste:

- Environmental sanitation
- Livestock health and productive agriculture
- Secondary rural industries
- Creation of new employment
- Reducing import of feed stuffs by upgrading local waste
- Price structure

Disposal of poultry waste

Dried poultry waste

The increased size of poultry units causes a tremendous accumulation of large amounts of manure. For instance, a flock of 100,000 layers kept in cages will produce more than 12 t daily.

Because disposal of poultry manure as a fertilizer is not very promising and hence increased interest has been developed in alternative method of waste disposal.

Alternative uses of poultry waste are fuel production and feedstuff ingredients. Recycling poultry waste after proper sterilization and processing has been advocated for incorporation in the Poultry feed in case of feedstuff shortage. Dry poultry waste varies widely in composition. However low-availability of energy content in poultry manure is the main limitation for its use in poultry diets. Non-Protein Nitrogen (NPN) in the poultry waste is also not useful for monogastrics. The essential amino acid content is limited, the average available aminoacid being 57% which low in comparison with feather meal (68%) and meat meal 82% (El Boushy and Roodbean, 1984).

A possible solution would be the biodegradation of cage layer manure by vermicompositing. The poultry waste can be processed by method like sun drying, steam heating and roasting and drum drying for its use as feed.

Disposal of poultry by-products waste

The tremendous growth of the poultry industry is creating a large amount of offals and wastes. If sufficient care is taken, the offal may contribute to animal feed as essential diet ingredients thus replacing parts of other expensive feed ingredients. The waste from poultry slaughter are blood, feathers and offal (viseera, heads and feet) and if collected separately can be processed into blood meal, hydrolyzed feather meal, poultry offal meal and fat etc.

Hatchery by-products consists of infertile eggs, dead-embryos, shells of hatched eggs and its use as feedstuff in poultry diet is being investigated (Miker 1984).

Poultry by-product meal

Poultry by-products processed by rendering can be divided into five general categories depending upon the composition of the raw material. They are:

- Blood meal which consists of ground dried blood.
- Poultry by-product meal which contains only clean, dry-rendered, wholesome parts such as the head, feet, undeveloped eggs, gizzards, and intestines, but not feathers, except the few that might be included in the normal processing and collection practices.
- Hydrolyzed feathers which are in the product resulting from the treatment of clean, undecomposed feathers, free of additives.
- Mixed poultry by-product meal which contains blood , offal and feathers, generally in their natural proportions. Mixed poultry by-products produce a more balanced product nutritionally than the other formulations, but it takes longer to process mixed by-products because feathers are harder to decompose or hydrolyze than offal.

Biohazards of poultry by-products

Poultry by-products such as feather meal, poultry by-product meal, hatchery by-products and shell waste used as animal protein feedstuffs are of a high nutritive value and safe for use in the formulation of poultry diets.

The processing of all these feedstuffs takes place by using high temperatures and pressure through batch cookers, by continuous cooking procedures or by extrusion at high temperature through friction. This processing results in a sterilized, completely germ-free product.

Concerning the processed spent hens, Lyons and Vandepopuliere (1996) stated that the extruded product produced Salmonella-negative ingredients with a marked reduction in the number of aerobic plate colonies, coliforms, yeast, and moulds.

Disposal of dairy waste

Between 75% and 85% of the water intake volume is discharged as effluent. Most dairy plant wastes respond to the biological treatment approach. The wastes are similar to municipal wastewater but considerably more concentrated and more readily degraded. The biological treatment approach most generally represents the best and most economical method of treating dairy wastes to reduce the BOD and COD concentrations to acceptable ones; Biological treatment of dairy wastes is, of course, widely provided in municipal treatment systems. Dairy plants also use the biological approach to treat wastes for stream discharge

Irrigation of the process wastes as a means of disposal is a viable approach for some dairy plants. The common methods of irrigation are: spray fields, spreading and ridge and furrow application. The plant has to own or have under lease adequate land of suitable type to take the volume of wastewater to be disposed of without runoff into the streams of the area. Further, the irrigation land must be close enough so it can be reached by pipeline or truck on an economical basis.

Dairy food plant wastes are treated primarily by biological oxidation methods. Biological oxidation is a function of the microflora of the waste treatment system, which in turn is dependent upon the composition of the wastes. The types of biological waste treatment methods utilized in the dairy food industry are primarily activated sludge, trickling filters, aerated lagoons, irrigation and a combination of these systems.

Wastewater Characteristics

Wastewaters from dairy plant processes normally include substantial concentrations of fats, milk proteins, lactose, some lactic acid, minerals, detergents, and sanitisers. Normally, a major fraction of the pollutants is in a dissolved organic and inorganic form not susceptible to plain sedimentation or flotation. The strength and quality of wastewater varies widely even within plants producing the same dairy food products.

Activate Sludge Process

One of the most popular methods employed for the treatment of dairy wastewaters is the activated sludge process. The process provides aerobic biological treatment employing suspended growths of bacteria The organisms are separated from the treated effluent by means of plain sedimentation.

Oxidation Ditches

The oxidation ditch is an extension of the activated sludge process employing a ring-shaped circuit or ditch usually 6 to 10 feet deep. The oxidation ditch may operate as a continuous system or as a batch process. operated in a continuous mode, a clarifier is incorporated as an integral part of the system.

Aerated Lagoons

Aerated lagoons are also an extension of the activated sludge process where in no sludge return is normally practiced. As a result, the active biomass in the lagoon is low, thereby requiring longer periods of aeration for comparable performance.

Stabilisation Ponds

Stabilisation Ponds cover a variety of lagoon systems employed for wastewater treatment. Stablisation ponds depend upon surface reaeration and photosynthesis for oxygen supply.

Trickling Filters

The trickling filter process in contrast to suspended growth processes employs a fixed support medium to maintain the active organisms within the wastewater stream.

Rotating Biological Discs

The rotating disc process is a modification of the trickling filter process whereby the fixed biological film is rotated through the wastewater. A large biological surface is provided by a series of closely spaced discs mounted on a rotating horizontal shaft.

Anaerobic Processes

The anaerobic treatment of diary process wastewaters has been practiced for many year in small dairy operations through the use of septic tanks. During anaerobic decomposition, lactose is rapidly converted to lactic acid, lowering the pH. In addition, fats and proteins are decomposed to amino acids, organic acids, aldehydes, alcohols, and other anaerobic intermediates.

Filtration

The filtration of wastewaters normally provides a polishing step prior to final discharge. Filtration may be provided by microscreens or granular filtration devices employing diatomaceous earth or sand or mixed bed filters of materials such as anthracite and sand or activated carbon and sand.

Chemical Methods

Chemical precipitation of dairy food wastewaters is not widely practiced primarily because of its high cost and its nominal effectiveness in organic matter removal.

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WHEY MANAGEMENT IN DAIRY INDUSTRY

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Whey is a slightly acid, yellow-green liquid which is the residue obtained from the coagulation of milk by rennet or by the lowering of its pH while manufacture of Cheese Casein, Paneer etc. A considerable volume of whey is produced in the world, and it has continued to increase in recent years Whey, a major dairy by-product, is receiving increasing attention for its proper utilization by the research workers all over the world. India has established itself as the world's largest milk producer and day by day the production of Cheese, *Chhana, Paneer* and other coagulated dairy products is increasing, leading to generation of huge amount of whey.

Whey is a by-product of dairy industry generated during manufacturing products like *Chhana, Paneer,* Cheese and Casein etc. Its composition varies widely depending on the variety and method from which it results. It is a good source of lactose, minerals, whey proteins and also rich in minor components like calcium, phosphorous, essential amino acids and most water soluble vitamins. Whey proteins contain about 2.5 g cystine and 2.8 g cysteine per 100 g of protein. Whey proteins have shown higher biological value (BV, 104), protein efficiency ratio (PER, 3.6) and net protein utilization (NPU, 95) than other protein sources, namely egg, beef, soy protein and casein. Whey proteins are also the most effective in meeting the body's energy and amino acid requirement and in this respect, it is superior to the above mentioned protein sources, widely recognized as nutritious. The total solids contents of milk and the composition varies from type of whey from which it is derived.

During recent past, the whey was drained to gutter by most of the dairy plants and private manufacturers. However, it lead to a serious problem of pollution as it posses a very high BOD and COD. It's decay lead to obnoxious aroma. Location of many dairy plants was identified by the peculiar aroma.

Constraints in Whey Disposal

It has been estimated that more than 125 million tones of whey is produced annually in the world, out of which 5 million tones is produced in India. In the world, 95% of whey is available through the production of whey, while in our country only 20 % whey represents the cheese whey and remaining 80 % is available through the production of Casein, Channa, Paneer etc. The high putrescibility of whey components is responsible for excessive biological oxygen demand (BOD) of whey, which renders it the most potent pollutant of all dairy waste. One hundred kg of liquid whey containing approximately 3.5 kg BOD and 6.8 kg chemical oxygen demand (COD) has the polluting strength equivalent to sewage produced by 45 people. This high BOD poses a major worldwide disposal / pollution problem equal in magnitude to that of whey. With the growth of the cheese making industry the increasingly larger quantities of non-utilized whey have resulted in greater pollution hazards, but the organization of pollution abatement campaign and better knowledge of the nutritional value of whey have led to a search for new ways of disposing of this by-product. Among the different solutions proposed, the utilization of whey in feeds for ruminants constitutes one of the newest and most rapidly exploitable means that may be adopted in the future. It is inexpensive, easy to put into practice and offers a good method of utilizing nonprotein nitrogen sources suitable for ruminants.

Therefore, many dairy organizations treat the whey before disposal. A study indicated that treating 5 lakh liter of whey in sewage would cost $ 10,000 (Rs. 470,000/-) per day for primary treatment and $ 145,000 (Rs. 68,15,000/-) for tertiary treatment. To overcome these problems, efforts have been made to develop new processes for effective utilization of whey.

Methods of Utilization of Whey

Diversion of whey solids to human chain by employing cost effective technologies, appears to be the best alternative for salvaging problems associated with the whey disposal. Today modern industrial processing techniques such as Ultrafiltration (UF), Reverse osmosis (RO), Microfiltration (MF), Nanofiltration (NF), Electrodialysis (ED), ion-exchange, new drying technologies, hydrolysis of lactose, fermentation of protein fractions etc. offer possibilities of using whey into major source of ingredients with different functional and nutritional properties, which could be used in food and dairy industry. Unfortunately, none of these technologies have been well caught up by the Indian dairy industry for the reasons best known to the industry.

Among the different ways of whey utilization, conversion of fluid whey as such or as permeate after UF into whey beverage is one of the promising ways to utilize whey. Whey based fruit drinks are thirst quenching, light and refreshing, healthful and nutritious, but less acidic than fruit juices and offer good potential profit margins.

There are various methods of utilizing or disposing of whey. It can be dumped at the production site, provided that the land area is large enough and the soil permits the absorption of the mineral elements and the organic matter. The principal constituents of whey (Table 1) can also be separated either by precipitation or by employing membrane technology like Microfiltration, Reverse Osmosis, Ultrafilteration, Nanofiltration etc. The resulting different whey solid fractions like WPC (Whey Protein Concentrate), Lactose, Minerals etc. can be utilized for the manufacture of value added products. Whey is also an excellent substrate for the cultivation of yeasts; there are various procedures, which make it possible to obtain large quantities of protein, lactic acid, ethyl alcohol and vitamins etc.

Whey can be processed into ingredients with functionalities for various applications. Simple concentration followed by drying is still the most common way of processing whey into value-added products. The concentration process may be combined with demineralization processes to change the applications of the final product to a more advanced level. The most valuable functional constituent of whey is the whey protein.

Whey Protein Concentrate (WPC) can be manufactured with different protein content. Due to its many nutritional and functional properties, WPC has a variety of applications in industry. The nutritional value is a plus in infant formulas and health products. The ability to bind water improves the texture in milk and meat products. The whipping and foaming ability improves the quality of certain ice cream and nondairy products. When manufacturing WPC, permeate is produced as well. This can be concentrated and dried into permeate powder that finds applications in desserts, bakery goods and instant products such as soups and drinks. The high lactose content in permeate may be processed to manufacture lactose. The lactose after proper refining, yield edible as well as pharmaceutical grade lactose. Lactose can be further modified to suitable form by employing different methods and thereby their applications can be increased in value addition of dairy and food products. The useful minerals from whey are predominantly calcium and phosphate. Although still limited, the demand for milk minerals within the food and health industry is increasing. Furthermore, whey contains valuable micro components, e.g. lactoferrin and lactoperoxidase. These are used as bactericides in infant formulas and toothpaste.

Utilization of Whey in Different Forms

1. Whey in Cheese making

Whey cheeses can be produced from whey by heating and separation of denatured proteins with fat. These cheeses have different names according to region they come from an dare made mainly in countries of the Mediterranean. Ricotta, Mysost, Manuri, Serac, Brocotte etc are the names of different whey cheeses. They differ in their composition considerably, mainly according to fat and moisture content. Whey cheeses are usually consumed fresh.

2. New Technologies, New Value

The development of separate markets for whey protein and lactose, and even for specific whey proteins, has been promoted by new membrane technology. This technology has reduced the costs of drying whey and allowed the refinement of whey without heat or chemicals. Membranes with microscopic holes, or pores, of various sizes are used to separate the components in fluid whey (or milk) according to particle size. Reverse osmosis (RO) membranes can remove up to two thirds of the water, leaving a concentrated fluid whey, which can be dried or shipped more efficiently. Ultra-filtration (UF) can separate water and lactose, leaving a fluid whey protein concentrate. Combinations of these and other membranes can be used to "fractionate" whey into almost any combination of its components for specific uses. This has contributed whole families of new whey-based ingredients for food processing. The greatest potential for fluid whey to capture real positive value is for the human food utilization. As the variety of whey ingredients has grown in recent years, so have their uses. Researchers in industry and academia continue to make great strides in developing valuable uses for this still inexpensive and highly versatile raw material.

3. Dried Whey

Improved drying technologies and equipments yield excellent quality of whey powder. It has long been used as a low-cost substitute for skim milk and nonfat dry milk in commercial baking and confectionery. It enhances color and binds water, which allows a moist product that doesn't get soggy. It is also used in ice cream to improve texture and add a sweet milk flavor that complements other flavors.

4. Acid Whey Powder

Acid whey comes from Ricotta and Cottage cheese production. Acid whey powder serves the same functions as sweet whey powder, but it adds a slightly tangy taste.

5. Reduced Lactose Whey

In reduced lactose whey, about a third of the lactose is removed, traditionally by crystallizing it and spinning it out. Demineralized whey contains significantly less ash, which is the mostly mineral components that normally make up nearly 10% of the whey solids. These products are typically substitutes for whey powder, modified to tweak the product recipe.

6. Whey Protein Concentrates

Whey protein concentrates (WPC's) are a range of products containing higher concentrations of protein, up to 90%. These have become economically achievable for many uses as a result of the new membrane technologies described above. One of these is WPC-34, (for 34% protein) which roughly approximates the composition of nonfat dry milk and so serves as an economical partial replacement for nonfat dry milk in many products, including many dairy products. This and other whey protein concentrates (WPC-50 through WPC-80), as well as whey protein isolate (which contains at least 90% protein) are used in food processing to boost protein content, add dairy flavor, and improve texture and handling. They can replace other dairy solids, egg whites, and fat.

Among the products containing whey ingredients are infant formulas, sports drinks, diet supplements, coffee whiteners, salad dressings, soups, baked goods and baking mixes, meats and sausage, gravies and sauces, cakes and pastries, chocolate, candy, fudge, pie fillings, crackers, pasta, mayonnaise, baby food, processed fruits and vegetables, and a wide range of processed dairy products.

7. Lactose Manufacture

Lactose is a by-product of most of the above products. It is the mild sugar, which can absorb and retain flavors and colors, replace other sweeteners, boost carbohydrates, provide a free-flowing dry medium for other ingredients, and increase shelf life. Among the products containing lactose are coffee whiteners, baked goods, confections, snack foods, all kinds of dry mixes, and many dairy products.

Most of these products are available in fluid forms, which many users prefer for their ease of handling. This avoids drying and reconstituting the product, and is feasible when it doesn't need to be stored for long. Whey proteins have found even higher-valued uses in pharmaceuticals and in simulating mother's milk in infant formula, while activated lactoferrin from whey has recently been launched as a commercial anti-bacterial treatment for meat. Such uses offer great opportunity to specialty processors. They also increase the overall demand for whey at the high end of the value scale; but we can only imagine a time that they will absorb enough whey to set the price for the last pound.

Exports are also a growing market for whey solids. U.S. exports of whey products have grown from 137 million pounds in 1994 to 435 million pounds in 2000; lactose exports grew from 104 million pounds in 1994 to 220 million pounds in 2000. Export uses vary as widely as domestic uses, so export growth contributes to raising the value of the last pound at every stage.

Conclusion

As long as large volumes of whey were going into the waste stream, the market value of fluid whey as it left the vat was zero, or less. The shift back to animal feed had little impact, except to offset disposal costs. But today, for the first time, new technologies are producing a growing value in the last pound of whey that can bring a return to both cheese processors and dairy farmers.

Whey values at near-parity with skim milk seem assured. The value added by our most innovative processors and the technology provided by our best dairy research is already benefiting the entire dairy community, as milk's components are ever more fully utilized and the value of the last pound of whey takes off.

Table 1: Composition of Different Whey Media

Type of Origin	Whey		Sheep	Goat
	Sweet	Sour		
	Percentage of defatted extract			
Lactose	78.8	69.7	65.9	63.0
Protein nitrogen (N x 6.25)	13.7	11.7	23.7	14.7
Nonprotein nitrogen	0.6	0.8	1.0	1.1
Lactic acid	0.5	11.6	2.3	13.9
Citric acid	2.0	0.4	1.3	0.2
Minerals	8.0	11.3	7.3	13.4
Phosphorus	0.6	1.0	0.7	1.1
Calcium	0.7	1.9	0.6	2.1
Potassium	2.2	2.3	1.7	2.9
Sodium	0.8	0.8	0.8	0.7
Chlorine	3.3	3.2	3.1	5.3

MANAGEMENT OF VEGETABLE AND FRUIT WASTES

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Crop wastes are defined as non- economic plant parts that are left in field after harvest and remains that are generated from markets/ storage yards/ packing sheds or that are discarded during crop processing. Adoption of mechanized farming in many advanced regions in the country has resulted in leaving a sizeable amount of crop or stalk in field after harvesting. Potential of crop residues of fruit and vegetable crops for recycling of valuable plant nutrients for sustained crop production is enormous. On national basis, not more than 1/3rd of these residues is available for utilization and in general, 50% of the nutrients are mineralized in the soil on decomposition in a cropping season. Estimates of agricultural waste availability in India suggest that the average quantity for crop wastes is 350 million metric tonnes and that of animal waste is 650 million metric tonnes. Effective management of these wastes is imperative in sustaining the environment and crop productivity. Inadequate collection and disposal of waste pose serious health risk to the population and is an obvious cause of environmental degradation in most of the developing countries. Mixed fruit and vegetable waste are dumped either indiscriminately in the neighbourhood or, if collected by a waste collection service, disposed of in uncontrolled dumpsites. The organic fraction of these wastes often contributing to more than 30% of the total quantity of waste, threatens health of inhabitants as indiscriminate waste dumps attract rodents and diseases carrying vectors. Organic waste is also responsible for pollution of soil and water bodies through leachate and in the process of uncontrolled anaerobic degradation; it contributes to global warming by production of methane. Management of agro food waste is particularly challenging, not only from a perspective of mass but also from a wide variety of forms to be handled.

The various resource-recycling alternatives are generation of value added products, cultivation of edible mushroom from lignocellulosic wastes, composting and biogas conversion. The fruit and vegetable wastes can be composted directly or can be put to value addition. It is simply not possible to list all the fruit and vegetable wastes in this write up. However, the ones, which are available in significant quantities with a potential for use, only are described.

Importance of waste utilization

- Wastes can be efficiently utilized.
- Minimizes pollution problems
- Byproduct recovery possible
- Offset the cost of raw materials
- Increases the cash flow and thereby increases the income of the processor
- Increases the capacity utilization of processing units.

Sources of waste generation: Inedible portions of fruits and vegetables that are discarded by consumers and processing units go as waste. These wastages take place under field level, market and storage level and from consumer and processing factories.

Operations	Types of wastes
1. Field level	Dropped, bird and insect damaged, Bruised and under utilized fruits & vegetables
2. Market and storage level	Damaged, shriveled and culled ones.
3. Consumer and processing	Cores, peels, seeds and pomace Factories

Of these, the field level wastes cannot be considered as wastes in true sense because these can be properly utilized if proper management are given. But with increase in production of processed products as a result of growth of processing industries, processing wastes generated are also increasing enormously. Utilization of these wastes not only reduces the pollution level but also economize cost of finished products and thereby increase income of processor.

Possible ways of waste utilization

1. Value added products

Any crop residue can be put to value addition. The nature of lignocellulose and availability of raw materials decide the end use. A combination of chemical and microbiological methods helps in processing crop residues in an ecofriendly manner.

Most of the wastes are rich sources of vital constituents like carbohydrates, proteins, fats, minerals and fibres. Chemical composition of many fruit and vegetable wastes is almost same, even though the quantity differs.

Table.1.Composition of different fruit wastes (per 100g)

Waste	Moisture (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	Carbohy drate (g)
Apple pomace	--	2.99	1.71	1.65	16.16	17.35
Mango seed	8.2	8.5	8.85	3.66	--	74.49
Jack fruit seeds	64.5	6.60	0.40	1.2	1.50	25.80
Jack seed flour	77.0	2.64	0.28	0.71	1.02	18.12
Banana peel	79.2	0.83	0.78	2.11	1.72	5.0
Sweet orange seeds	4.0	15.80	36.9	4.0	14.0	--

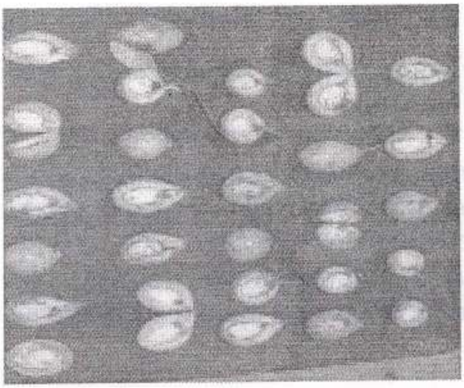
Source: Apsara (2001)

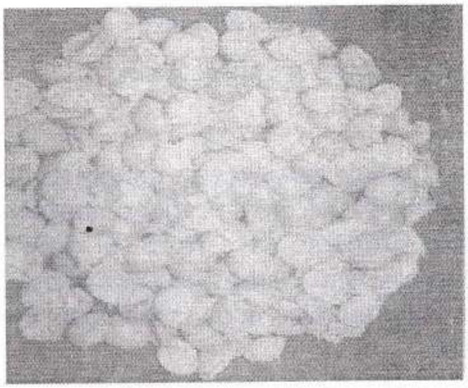
Pectin extraction from fruit wastes

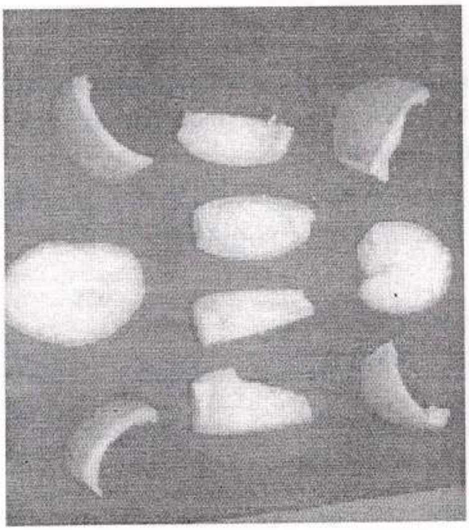
Fruit wastes can be effectively utilized for production of enzymes like pectinase. Among different enzymes, used in fruits and vegetable processing industries, pectinase occupies prime position. Ideal fruit waste medium for maximum enzyme production is a mixture of 5g waste, 0.75g urea, and 0.3g ammonium sulphate and the optimum temperature is 40^{0}C and the extraction is to be done at 8 days after inoculation using extractant distilled water (Venkatesh, 2003).

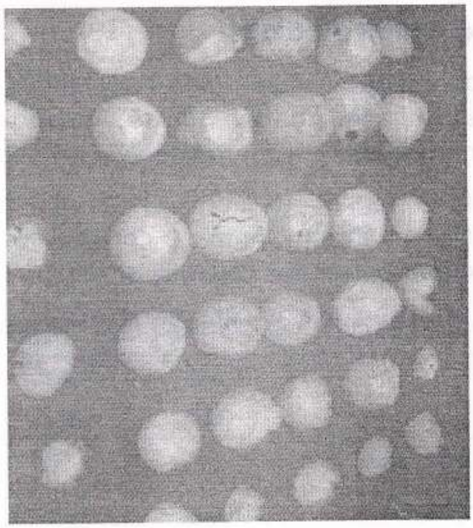
Different fruit wastes and their products for pectin extraction (Source : Apsara 2001)

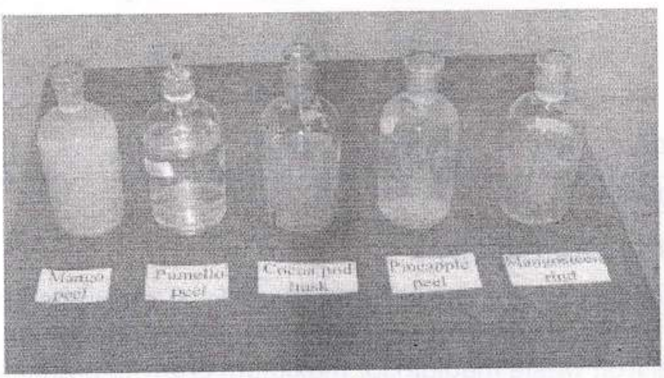
Nutmeg **Citrus**











Pectin extracts from different fruit wastes

By products from wastes

Industrial processing of mangoes end up with considerable proportion of stones and peels. Stone content of mangoes ranges from 9-23% with an average of 15%. According to one estimate, o.3 million tonnes of dry mango kernels are available annually, from which 30,000 tonnes of mango fat valued at Rs. 20 crores would be obtained.

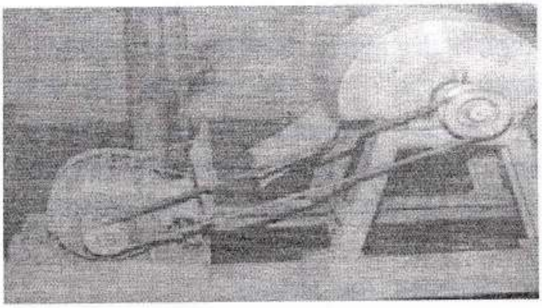
Fat, starch, essential oils, natural colours etc included under various products obtained form fruit and vegetable wastes. All these can be effectively utilized for animal and poultry feed, processing industries, textile production etc. A short account of the same is provided in Table.2 as follows.

Table.2. Products from different fruit wastes

Fruit crop	Products	Reference
MangoMango peel	Pectin, fruit fibre, carotenoid pigments, vinegar, wine, tannins and starch	Sanjeevkumar (1994)
Mango stone	Oil, fat , poultry feed	Tandon & Kalra (1989)
Pineapple		
Core	Sugar syrup, citric acid, candies	Devi & Ingle (1982)
Peel and leaves	Biogas, oleoresin, wine, fibre, waxes	Joshi & Joshi (1990)
Peel and pulp	Nata-de-pina	Hegde (1997)
Jack fruit		
Rind and core	Pectin, fibre	Vilasachandran (1985)
Seeds	Flour, starch	Berry& Kalra (1988)
Banana		
Peel	Banana cheese, pectin	Mohammed&Hassan (1995)
Citrus		
Peel and pulp	Pectin, essential oil	Anand& Maini (1997)
Lime sludge	Candy, citric acid	Girdharilal et.al (1998)
Orange wastes	Livestock feed	Anand& Maini (1997)
Lime pomace	Carbonated beverages	Khurdiya et.al (1997)
Guava		
Pomace	Citric acid	Kapoor et.al (1982)
Peel	Cheese	Srivastava & Sanjeevkumar (1994)
Papaya		
Ripe fruit & green fruit lanced for latex extraction	Pectin, papain, tuti-fruity	Girdharilal et.al (1998)

Source: Apsara (2001)

Mechanical extraction



a. Raspador machine

b. Feeding of sheath

Banana pseudostem for retting

Table.3. Composition of different vegetables (per 100 g)

Vegetable	Fat (g)	Protein (g)	Carbohy drate (g)	Fibre (%)	VitaminA (I.U)	VitaminC (mg)
Cabbage	2.0	1.4	5.7	1.5	70	46
Carrot	0.19	1.2	10.6	---	12000	4
Amaranthus	0.34	4.0	1.12	1.2	9200	99
Tomato	0.30	1.0	4.0	0.60	1100	23

Source: Shanmugavelu (1989)

Table.4. Products from a few vegetable wastes

Vegetables	Product	Reference
Water melon		
Seeds	Oil	Singh and Bains (1981)
Rind	Preservatives and candies	Uddin and Swamy (1981)
Peel	Pectin, pickle processing	Teotia *et al.* (1988)
Cabbage		
Processing waste	Protease and cellulase enzymes	Krishna and Chandrasekharan (1995)
Carrot		
Processing waste	Microbial production of citric acid and lactic acid	Garg and Hang (1995)

Source: Apsara(2001)

Fibre extraction from banana pseudostem

The banana and plantain pseudostem sheaths can be utilized for fibre extraction in three ways:

1. Hand extraction
2. Machine extraction
3. Extraction by retting.

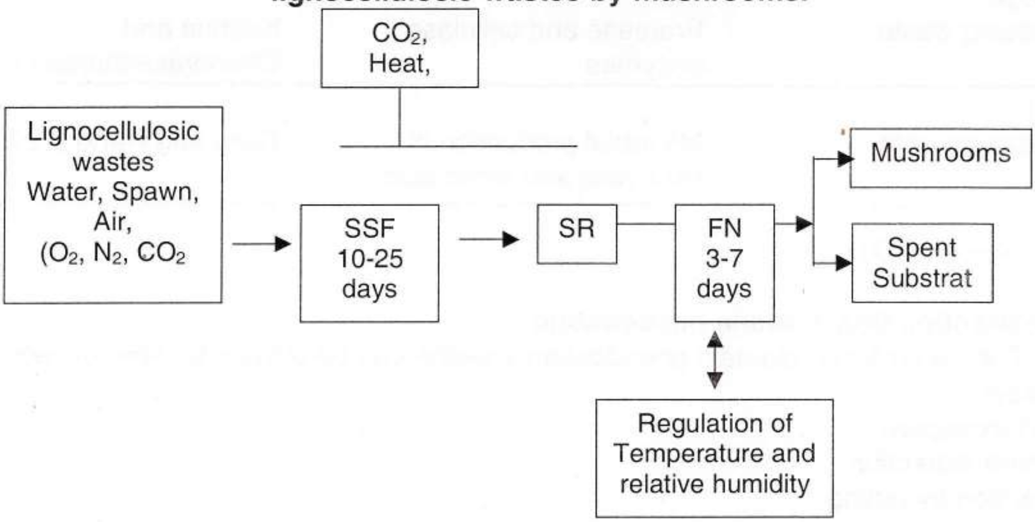
Extraction by manual method

Fibre extracted under hand method of extraction is of less wet weight, less dry weight and low percentage of recovery. In mechanical extraction, fibre with comparable values of wet weight, dry weight and percentage recovery is obtained. In retting method of extraction, maximum wet and dry weight is obtained with retting agent, 2% sodium hydroxide (Gopinath, 2005)

2. Recycling of lignocellulosics for food

Chemically plant wastes are lignocellulosics, composed of various levels of lignin, cellulose and hemi cellulose. In fact, the only proven microbial means of converting unmodified material is found in the biodegradability of various types of mushrooms which are the white rot fungi belonging to class basidomycetes. Growth of these mushrooms on lignocellulosic wastes is primarily, the concept of solid-state fermentation related to absence or near absence of free liquid, corresponds to moisture content up to 80% and empty space is filled by a gaseous phase and mushrooms use undissolved materials for their growth and metabolism.

Inputs and outputs during solid-state fermentation (SSF) of lignocellulosic wastes by mushrooms.



SSF: Solid State Fermentation, SR: Spawn Ramification, FN: Fruitification

Source: Savalgi (2001)

The yield from Pleurotus quebeca is 1.20 kg per 10 kg of substrate when banana leaves are used as substrate and that of Pleurotus pulmonarious is 2.60 kg when bean leaves are used as substrate.

3. Ecofriendly fertilizers from wastes

Composting garbage for production of fertilizer through organic waste treatment is becoming popular. To make a widely acceptable compost system especially in urban areas, a few issues such as logistics between suppliers of compost and agro industries, preparation of garbage components and water content and deodorization should be cleared. Composting is a process by which organic wastes are converted into organic fertilizers by means of biological activity under controlled conditions.

It is an important technique for cycling organic wastes and for improving quality and quantity of organic fertilizers. It is a natural biological process that is carried out by various natural microorganisms, including bacteria and fungi that utilize solid waste as an energy source and breakdown organic material in to simpler substances. Objectives in composting are to stabilize organic matter in raw wastes to reduce offensive odours, to kill weed seeds and pathogenic organisms and finally to produce a uniform, slow release organic fertilizer which stimulates soil life.

Major benefits of compost

1. Improved plant and root growth
2. Reduced rate of nutrient release
3. Improved soil porosity
4. Improved water holding capacity
5. Plant disease suppression.

Rapid composting methods

While traditional composting procedures take as long as 4-8 months to produce finished compost, rapid composting methods offer possibilities for reducing the processing period up to three weeks. A variety of approaches and their combination are used to hasten composting process, which include the following.

- Shredding and frequent turnings
- Use of chemical nitrogen activators
- Use of effective microorganisms
- Use of worms
- Use of cellulolytic cultures
- Use of forced aeration
- Use of forced aeration and mechanical turnings.

Shredding and frequent turnings: The Berkley rapid composting method corrects some of the problems associated with the old type of composting. With this process, compost can be made in two or three weeks. Factors essential to this technique are as follows:

1. Materials will compost the best if it is between 2.5 and 3.75 cm in size.
2. Materials should have a C/N ratio of 30:1. Mixing equal volume of fruit and vegetable wastes with equal volumes of naturally dry plant material may provide this ratio.
3. Soil, ashes and manures from meat eating animals should not be added to the compost pile. But manures from herbivorous animals can be added to hasten the decomposition process.

4. Once a pile is started, do not add anything since it will lengthen the period of composting.

5. Composting work the best if the moisture content in the pile is about 50%.

6. A pile at least 90x90x90 cm is recommended for heat retention. Microbial decomposers function at 71°C. The compost pile needs to be turned to prevent pile from getting too hot.

Use of mineral nitrogen activators

Compost piles with a height of 1.8m are revised. To keep aerobic bacteria population high and active, 3.24 kg of actual nitrogenous fertilizer should be added per cubic meter of dry matter (North Dakota State University Host composting method).

Use of effective microorganisms (EM)

A unit plant consists of nine pits of 180 cm (long) x120 cm (width) x 90 cm (depth), enclosed by low walls and covered with roof. The EM solution functioning as accelerator reduces composting period from 3 months to 6 weeks.

Use of worms: A moist heap of 2.4m x 1.2mx 1.2mxo.6m can support a population of more than 50000 worms. Introduction of worms into a compost heap is found to mix the materials, aerate the heap and hasten decomposition. Turning heaps is not necessary if earthworms are present to do the mixing and aeration. Ideal environment for the worms is a shallow pit and the right sort of worms is necessary such as *Lumbricus, rabellus* and *Eisenia foetida*.

Use of cellulolytic cultures

The cellulose decomposer fungus, *Trichoderma harzianum* grown in a medium of sawdust mixed with leaves of a leguminous tree is termed as compost fungus activator. The procedure consists of two parts, the production of the compost fungus activator and the composting process.

Use of forced aeration

The aerated static pile method takes the piped aeration a step further, using a system blower to supply air to the composting materials. The blower provides direct control of the process and allows larger piles. When the compost pile has been formed and if the air supply is sufficient and the distributor is uniform, the active composting period will be completed approximately in 3 to 5 weeks.

Controlled systems with forced aeration and accelerated mechanical turnings.

In vessel composting method, a variety of forced aeration and mechanical turning techniques to speed up composting process are followed. Within a building, container or vessel is used. Many methods combining techniques from windrow and aerated pile methods are followed to overcome the deficiencies and exploit the attribute of each method.

Silo is an in-vessel technique, which resembles a bottom-unloading silo. This system minimizes the area needed for composting because materials are stacked vertically. However, stacking also prevents compaction, temperature control and air flow which must be overcome. Because materials receive a little mixing in the vessel, raw materials must be well mixed when loaded into the silo.

Composting materials

Vegetable and fruit wastes are ideal for a compost pile. The pile needs a proper ratio of carbon rich materials (brown) and nitrogen rich materials (green). Among the brown materials are dried leaves, straw and wood chips. Nitrogen materials are the waste materials. Mixing contains types of materials or changing the proportion can make a difference in rate of decomposition. Achieving the best mix is more an art gained through experience. Ideal ratio approaches 25 parts browns to 1-part greens. Judge the amounts roughly equally by weight. Too much carbon will cause the pile to breakdown too slowly, while too much nitrogen can cause odour. The carbon provides energy for the microbes and the nitrogen provides the protein.

Blending carbonaceous substances like sawdust, paper and straw can be mixed with nitrogen rich materials to obtain a near optimum C/N ratio of 30:1 or 40:1. A varied mixture of substances produces good quality compost rich in major and micronutrients.

Household management of fruits and vegetable wastes

Recycling of Agrowastes Through Vermicomposting

↓

Enrichment of Compost with Suitable Organic Manures

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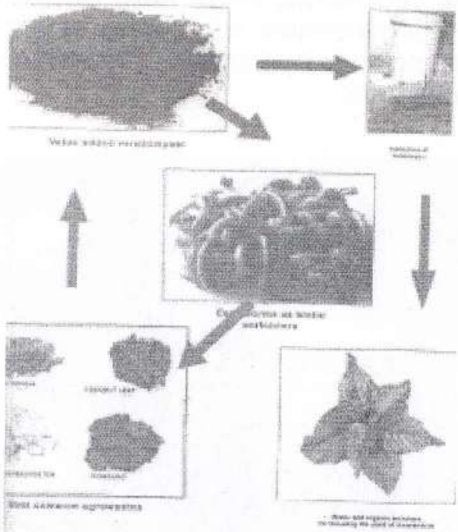
Collection of Vermiwash Rich in Nutrients, Beneficial Microbes, Hormones and Enzymes

↓

Ferigation to Crops

↓

Good Quality Leafy Vegetables for Healthy Life



Recycling of organic wastes for good quality vegetable production
Source: Thankamony (2005)

The above figure narrates flow chart of strictly an organic enrichment process towards accomplishment of quality food and healthy life through vermitechnology. Value added vermicompost can be prepared with use of vegetable and fruit wastes. The worms, which act as bio enrichers liberate nutrients, secrete hormones and vitamins and ultimately they themselves dissolve as nourishments. So enriched vermiwash may be collected which can be further used for fertigation to vegetable and fruit crops.

4. Bioconversion

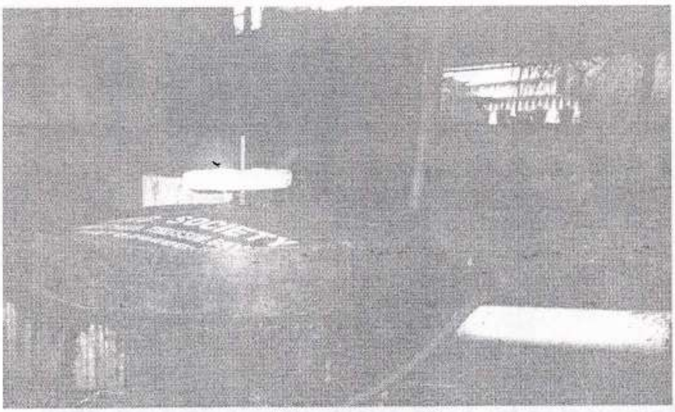
Bioconversion is the process of recovering useful energy from biomass. In bioconversion, choice of process is determined by a number of factors like location of resource, its physical condition, economics of competing process and end use required.

Bioconversion can be done generally in three different ways namely,

1. Direct combustion
2. Thermo chemical conversion
3. Biochemical conversion.

Direct combustion is the simplest and the most commonly employed form where biomass is directly burnt. Thermo chemical conversion is nothing but gasification where wood biomass is used. Biochemical conversion consists of anaerobic digestion and fermentation. On other hand, methane fermentation is the principle suitable for watery garbage. However it has been difficult to apply the process to waste-source treatment because of relatively large bioreactor dimension requirements due to slow digestion speed. To make waste-source treatment possible for garbage, a thermophilic methane fermentation system with energy recovery are developed. The biogas unit consists of a pre treatment process for raw organic wastes, methane fermentation process that is a fixed modified bid bioreactor, the biogas utilization process to produce electricity and /or hot water and the secondary aerobic treatment process for wastewater.

Some of the fruit and vegetable waste can be usefully diverted for biogas generation and making field manures. Unlike vegetables, which have Ph in neutral range, fruits are not suited for active fermentation in generators due to their acidic nature. Neutralizing agents like lime slurry are added along with fruit waste for continuous active fermentation and maintaining efficiency of biogas units.

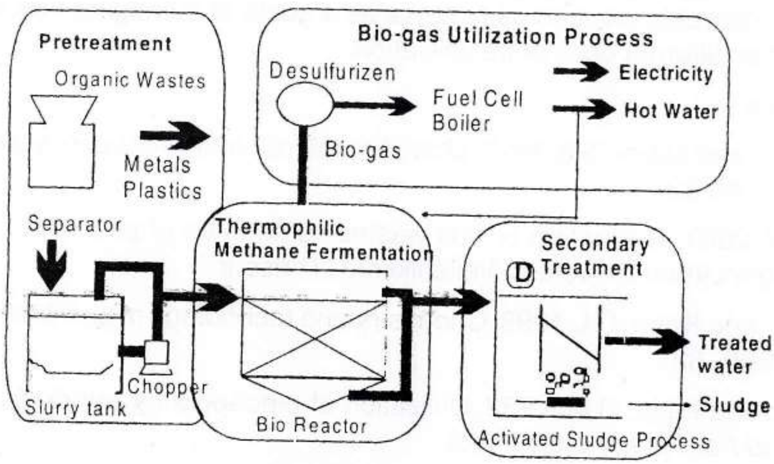


Biogas unit

The process of digestion leading to generation of methane can be grouped in to three distinct stages. In the first stage, insoluble biodegradable items like cellulose, fats etc are broken down to soluble carbohydrates and fatty acids. This occurs in about a day around 25°C in an active digester. In the second stage, acid forming bacteria produce mainly acetic and propionic acid. This stage also occurs in a day at 25°C. In the third stage, methane-forming bacteria act slowly and in about 14 days (at 25°C), complete the digestion, producing mainly methane and carbon dioxide, which constitute biogas. The sludge left behind after gas generation is an enriched fertilizer. Agro food wastes are produced as liquids either rich in suspended solids or dissolved solids, semi liquids, semi- solids and finally solids. To deal with this variety of forms, Bioenvironmental Engineers have developed various handling and storage systems. To demonstrate the complexity of managing agro food waste, garbage collection can be examined. Garbage is a solid waste only. All handling and disposal tools are designed for solids. On the contrary, a factory processing vegetables for canning or freezing, must deal with several forms of wastes. The first is wastewater produced from washing the vegetables and from transporting them. Often, water is used to hydraulically transport the vegetables from one operation to another. The second is the solids from the cutting and trimming of vegetables. While wastewater can be pumped, the solid wastes must be conveyed or handled with a bucket. While the wastewaters are stored in circular tanks, solids must be stored on a floor with walls catching the drainage. While the waste waters can be aerated to concentrate their pollutant load into sludge, the solids can either to be send to a landfill site or to be composted.

Waste source treatment for garbage has significant advantages from both economical and environmental points of view. These are,

1. Reduction in final disposal cost.
2. On site utilization of by-products and / or energy.
3. Reduction in operational hours of the packer taken for collecting garbage.
4. Improvement on thermal qualities of combustible wastes by reducing water content.
5. Reduction in methane gas emission from final disposal sites.



Source: Organic Farming, Vol.2

Conclusion

A number of by products can be recovered from various fruit and vegetable wastes. The attempts made for its exploitation seem to be little. The reasons for non- utilization of wastes are many. As most of the processors operate on a small scale and so the quantity generated may not be sufficient to treat profitability. Also, since the functioning of processing units are seasonal and the character of waste differs from season to season, the technological requirement also varies. Because of food industries being small to medium size, quantity of waste generated is sometimes enough to justify byproduct recovery.

The economic value of an organic waste or residue to a farmer is the value of the increase in crop yields and or crop quality that is derived from its use. Since crop yield response to an organic amendment follows the law of diminishing returns, farmers can be expected to utilize organic materials to the point when revenue from incremental unit is equal to its price assuming application is included in the price. Thus an estimate of the value of the incremental waste is necessary by management agencies when analyzing the marketability of the recycled product. However, public decision makers should also be interested in the estimates of the total economic benefits. Let us summarize the various problems in waste utilization:

Table.5. Problems and prospects of waste utilization

Problems	Prospects
Unawareness among people pertaining the possibilities of waste utilization	Good extension work need to be done in this field
Insufficiency of raw material due to scattered nature of processing industries	Technology for proper transportation of waste with out degradation
Lack of standardization and popularization of accepted products	Production, evaluation and popularization of acceptable products
Ensure economic feasibility	Economic feasibility analysis and recommendations on that.

The ideal prospects will lead us to serve as a guide in managing fruit and vegetable wastes generated at different sites of its utilization.

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FRUITS AND VEGETABLES WASTE MANAGEMENT INDIAN SCENARIO

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Agriculture and allied activities contribute about 30 per cent to GDP of India. Horticulture is one of the promising sectors in agriculture as it holds the key to accelerate the economic growth of the country in agricultural sector. Horticulture is the key component for attaining 6-7 per cent growth rate of agriculture per annum. The major components of production process which require immediate attention to achieve and sustain this kind of growth rate in horticulture are availability of quality planting material, better production system management, improved post harvest management and effective waste management.

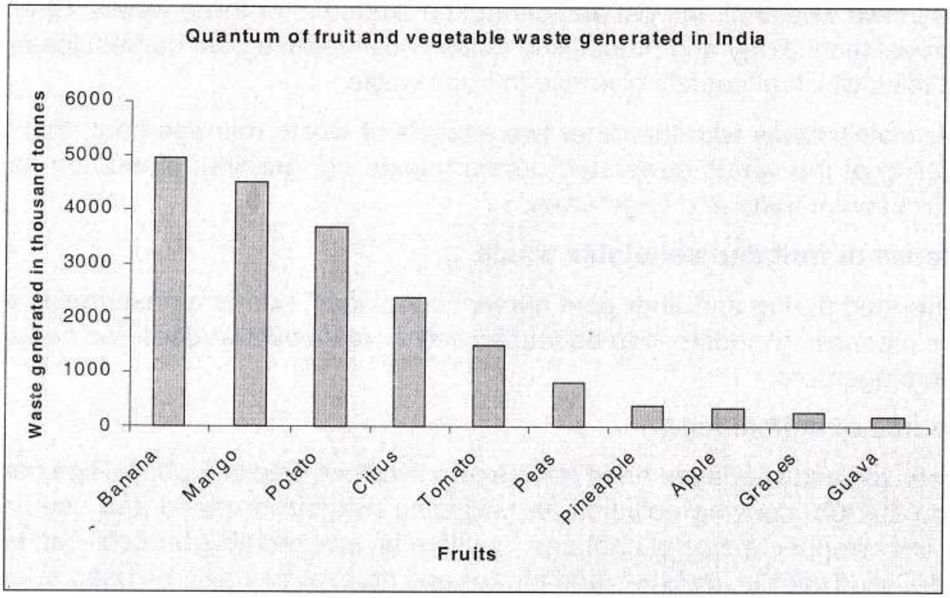
India is one of the major producers of fruits and vegetables and ranks next only to Brazil and China in the world. It contributes 10% of world fruit production and 14% of world vegetable production. In post WTO Scenario, cost effective production of horticultural commodities, their post harvest management, value addition and marketing has assumed a great significance. Fruits and vegetables are more prone to spoilage than cereals due to their nature and composition, and this spoilage occurs at the time of harvesting, handling, transportation, storage, marketing and processing resulting in waste. These wastes can be a source of atmospheric pollution and contamination if left unattended. Efficient management of these wastes can help in conserving vital nutrients of our foods and feeds, and bringing down the cost of production of processed foods, besides minimizing pollution hazards. According to Indian Agricultural Research Data Book 2004, the losses in fruits and vegetables are to the tune of 30 per cent. Taking estimated production of fruits and vegetables in India at 150 million tonnes, the total waste generated comes to 50 million tonnes per annum.

1.1 Quantum of waste generated by fruits and vegetables

Ten most important fruits and vegetables listed in table 1 reveal that maximum waste is generated in banana followed by mango, potato and citrus. Percentage wise highest waste is produced by citrus which is around 50% followed closely by mango which is to the tune of 45%. Since, India produces huge quantity of banana and mango and citrus, these three fruits contribute maximum to the waste. Among the vegetables, peas account for 40% waste but the quantum of waste generated by peas is only to the tune of 815000 metric tons. Though potato generates only 15% waste but the production and productivity of potato being high, it accounts for more than 3.6 million tonnes metric tonnes waste.

Table1. Quantum of waste from major fruits and vegetables in India

Major Fruit/vegetable	Percent waste generated	Quantum of waste (000' MT)
Banana	35.0	4973.43
Mango	45.0	4509.09
Potato	15.0	3668.40
Citrus	50.0	2394.55
Tomato	20.0	1492.46
Peas	40.0	815.28
Pineapple	35.0	390.09
Apple	29.5	341.72
Grapes	20.0	241.94
Guava	10.0	171.55
Total	10-50	18998.46



1.2 Problems created by fruit and vegetable waste

Following are the important problems created by fruits and vegetable waste:

1.2.1 Loss of human nutrition and plant nutrients

Fruits and vegetable are known to be the best health food and they are rich source of vitamins, carbohydrates, minerals, pectin, proteins, and amino acids. Their loss resulting from inefficient post harvest management, culled fruits and vegetable waste from processing, marketing and human consumption is a vital loss of human and animal nutrients besides plant nutrients those become available to plants after decomposition.

1.2.2 Pollution and sanitation problem

Fruit and Vegetable being highly perishable are prone to spoilage and their waste during handling and marketing cause's atmospheric pollution. Further, more the waste generated from the cannery and processing industries further add to the pollution.

2. MANAGEMENT OF FRUITS AND VEGETABLES WASTE

Rapid growth of horticulture and its role in economic development in India has resulted in tremendous increase in the waste generated by fruits and vegetables. A three-pronged strategy can be applied for the management of fruit and vegetable waste. The important three Rs of this strategy are:

Reduction of waste

Reuse of waste

Recycling of waste

2.1 Reduction of fruits and vegetables waste

It is a matter of common observation that perishables like fruits and vegetables lose half their quality within two weeks of harvest and cannot be graded after three weeks. Strengthening of post harvest technology and processing industry can reduce post harvest losses of fruits and vegetables which ultimately give rise to huge waste

This paper mainly deals with the other two aspects of waste management, that is, Reuse and Recycling of the waste generated during harvesting, grading, marketing, processing and consumption of fruits and vegetables.

2.2 Reuse of fruit and vegetable waste

Waste generated during and after post harvest operations, human consumption as well as waste from processing industry can be reused and more innovative uses can be explored for effective management.

2.2.1 Source of animal feed

Orange peel, rag and seeds are dried for use as a livestock feed in Florida. Ripe banana peel constituting 20-30% causing pollution and skidding risk can be dried and used as poultry feed. The non-wrapper leaves of cabbage, cauliflower, and heading broccoli can be used as cattle feed. Culled carrots, radishes and turnips and broccoli can also be used as cattle feed. Apple drops and culled fruits after slicing and partially drying are generally used as cattle feed. Pineapple bran has a great demand as a cattle feed in Hawaiian Islands. Apple pomace, dried or fresh, can be used as animal feed. There is need for research and development to develop new feed for other animals such as poultry, fish, pigs, sheep and other animals.

2.2.2 Pickling

Many fruits and vegetables not of marketable grade can be used for pickling and value-addition. Mango, aonla, lime and lemon, small onions, cauliflower, raw papaya, culled carrots, radishes and turnips are some examples.

2.2.3 Edible oils from kernels

The kernels of stone fruits such as peach, plum, and apricots are successfully used as a low-cost source of edible oil and it is a well established cottage industry in H.P.

2.2.3 Silage

In India, fruits and vegetables waste is normally fed fresh to the cattle and other animals. However, these wastes can be effectively used as fermented feed after ensilage. However, crop residues such as pea vines may be incorporated along with corn for silage because alone these may undergo putrefactive changes during ensilage unless mixed with other materials low in protein and rich in carbohydrates.

2.2.4 Extraction of new products from the waste Pectin

Majority of pectin produced in the world is extracted from citrus peels. Pectin is used mainly for jam making, pharmaceutical and several other industries. Two citrus processing units in Uttrayan, and Kodur are producing lime pectin in a small quantity. India is still importing about 160 tonnes of pectin valued at about Rs.10 crores for fruit and vegetable processing industry alone. Manufacture of "Genu" pectin in Denmark, almost commands a virtual monopoly by organizing year round production after procuring dried citrus peels of requisite quantity from different parts of the world. Mango peel which is available from processing factories is also a good source of pectin (Table 2).

Table 2: pectin obtained from different fruit sources

Fruits	Yield % (dry wt)
Galgal	26
Assam lemon	20
Mango peels	16
Apple pomace	16

Producing pectin through microbial activity is advanced technology as pectin prepared by chemical method is a tedious and corrosive process. Pectin produced by growing microorganisms on waste of processing industries particularly, citrus peels by using Trichosporon penicilliatum is of high quality and more efficient method of pectin production.

Starch

Banana pseudostem having a yield of 20-25 tonnes from about 1000 banana plants, when extracted, gives about 5% edible starch. The method for strarch extraction from pseudostem has been standardized and physico-chemical properties of starch have been studied. Likewise, 1,40,000 tonnes of starch may also be available from mango seed kernels.

Natural colours

It is an ancient practice to add colours to the food to make it more attractive. Earlier, natural colours were used for this purpose, but now-a-days synthetic colours like coal tar dyes are employed. Due to their carcinogenic effects, coal tar dyes are being replaced rapidly by natural colours or plant pigments for use in food products. Natural colours of blue grapes skin, kokum (*Garcinia indica*), phalsa (*Grewia subinaequalis*) and Jamun (*Syzygium cumini*) have been thoroughly investigated for their nature, concentration, extractability, stability and suitability as food colours. Methods for making colour concentrates and powders from them have also been developed. A new fat soluble yellow pigment, garcinol was isolated from rind of kokum. Many vegetable wastes such as peels of onion, non-wrapper leaves of red cabbage, Culled carrots are a rich source of natural red, purple and yellow pigments.

2.2.5 Miscellaneous products

Charcoal from left-over decortications of stone fruit kernels and walnut shells is quite important. In addition dried rind of pomegranate fruits is a good source of natural dyeing and leather tanning materials besides its use in pharmaceutical industry.

2.3. Recycling of fruit and vegetable waste

Recycling of fruit and vegetable waste is one of the most potent means of utilising it in a number of innovative ways yielding new products and meeting the requirements of essential products required in human, animal and plant nutrition as well as in the pharmaceutical industry. This point has been dilated by following description:

2.3.1 Microbial technology for recycling of processing waste

These can be grouped as:

i) Fermented Edible Products

ii) Single Cell Proteins

iii) Enriched animal feed

iv) Ethanol

v) Enzyme

vi) Food Additives

vii) Organic Compounds

viii) Composting

ix) Biogas

Fermented Edible Products

A number of beverages such as cider, beer, wine and brandy, and vinegar can be obtained from the fermentation of fruit waste. Apple pomace has been utilized for the production of cider and the quality of drink was improved by carbonating it. Good quality apple cider and brandy by fermenting milled apple pulp has been produced. The possibility of making brandy from dried, culled and surplus apples, grapes, oranges and other fruits has also been explored.

Vinegar can also be prepared from fruit wastes. The fruit waste is initially subjected to alcoholic fermentation which is followed by acetic acid fermentation by Acetobacter bacteria which produce acetic acid. Vinegar production by fermenting waste from pineapple juice has been reported. Vinegar production by fermenting orange peel juice has also been attempted successfully. It can also be produced by mixing apple pomace extract and molasses in the ratio of 2:1.

Single Cell Proteins

Single cell proteins can be produced from dried and pectin extracted apple pomace by using Trichoderma viride and Aspergillus niger. The grape waste and pressed apple pulp have also been employed as a subtrate for Asperigillus niger to generate 35% crude protein and cellulase. Pineapple waste for SCP production has also been utilized. Citrus peel juice has also been used to generate SCP by using Fusarium.

The waste from brewery and distilleries can also be used for the production of single cell proteins. SCP can also be produced from baked bean waste using Aspergillus fotidus. Symba-yeast on potato waste has successfully been propagated. Potato peels supplemented with 0.04% ammonium chloride have also been used for the production of protein by using a non-toxic fungi Pleurotus ostreatus. Similarly, waste from orange, sugarcane and grape processing industry have also been utilized for the production of SCP.

Enriched Animal Feed

The waste obtained from processing of fruits and vegetables is rich in fibre, which includes cellulose, hemi cellulose, lignin and silica with poor quantity of protein. Fermented potato waste has been successfully tried as an animal feed. When sweet potato waste was fermented with fungi imperfecti its protein content increased up to 31.6%. Apple pomace after fermentation with different yeasts and drying becomes enriched with proteins, vitamins, minerals and fats, and it can be used for feeding animals. Waste from wineries, breweries and distilleries after fermentation can also be used for feeding livestock. Animal feed can also be obtained from grape pomace after fermentation. It was reported that dry brewer's grains after addition of molasses become a very good cattle feed.

Ethanol

The waste from fruits and vegetable processing industries being rich in polysaccharides (cellulose, hemicellulose and lignin) can be subjected to solid state fermentation (SSF) for the production of ethanol which has several uses. It can be used as a liquid fuel or liquid fuel supplement and as a solvent in many industries. A SSF process for production of ethanol from apple pomace was developed. Pear and cherry wastes have also been utilized for production of ethanol. Orange peel after enzymatic hydrolysis was found suitable to SSF by use of Saccharomyces cerevisiae.

Enzyme

Both submerged fermentation (SF) and solid state fermentation (SSF) are generally employed for production of enzymes. But SSF is a better method than SF for production of enzymes. Various enzymes have been produced by fermenting food processing waste (Table 8). Invertase enzyme by fermenting Sauerkraut waste with the help of *Canidida utilis* was attempted. Native microflora has to be utilized for generation of enzymes from cabbage waste. The enzymes produced were amylase, protease and cellulase. Bacterium *Pseudomonas* was the predominant micro-organism involved in the fermentation.

Food processing waste used and enzymes produced through microbial fermentation

Waste	Micro-organisms utilized	Enzyme produced
Apple pomace	*Trichoderma viride*	Cellulase
Grape wine trimming dust	*Aspergillus spp.*	Xylanase
Sauerkraut waste	*Cerrena unicolor*	Cellulase
Sugar beet pulp	*Candida utilis A.* phoenicis	Cellulase, Xylanase and Ligninase

Food Additives

Solid state fermentation with Aspergillus niger on various substrates like pineapple juice, molasses, sweet potato residue, sugar-cane bagasse impregnated with pineapple juice, mandarine orange waste, apple pomace, grape pomace can be used for citric acid production.

Microbial Flavours and Gums

Microbial gums like xanthan can be produced from processing of waste. *Xanthamonas campestris* has been employed to produce xanthan from fermentation of cabbage waste and citrus waste.

Amino Acids

Amino acids have also been produced by microbial fermentation of waste. These amino acids are used as additives in food, feed and also as flavouring agents. Glutamic acid is one of the amino acid which is produced by fermenting hydrolyzed starch solutions, cane molasses and beet molasses by using bacteria like *Corynebacterium glutamicum.*

Vitamins

Microbial fermentation can also be used for production of vitamins which are very important biomolecules and their deficiency can cause several diseases in human beings and animals. Bacteria *Pseudomonas denitrificans, Propionibacterium shermanii* and *Streptomyces* have been used for commercial production of vitamin B_{12} from soybean meal, corn steep liquor, fish meal, meat extract, etc.

Composting

Nutrient recycling through compost making from the waste of fruits and vegetables has gained importance as a means to conserve plant nutrients as well as its potential for use in organic farming. Organic wastes are an important natural renewable resource of plant nutrients. Waste from fruits and vegetables market should be kept separate from municipal waste for composting.

Biogas Production

The waste material from various processing industries like food, agriculture, fruits and vegetable processing industry can also be subjected to anaerobic treatment process (AnTP) for biogas production.

3. CONCLUSION AND FUTURE STRATEGIES

It is apparent from the foregoing discussion that fruit and vegetable production generates a large quantity of waste. The processing of fruit and vegetable also adds to the quantity of waste which is highly biodegradable. Nevertheless, the waste generated from fruit and vegetable processing is a rich source of nutrients including minerals, vitamins, carbohydrates and fibres. Therefore, I think, the waste from fruit and vegetable processing in real sense is not a waste as every thing can be profitably recycled, bio-converted and utilized in one or the other form as food, feed or fodder. Hence, our strategy should be to make the use of the waste in a profitable manner.

A crisp review of the technologies developed for waste utilization would reflect the development of several technologies which if employed could result in production of many value added products. A large quantity of waste can be used for recovery of valuable products such as starch, pectin, citric acid, tartaric acid, oils, fats, carotenoids. Ethanol is one of the several options available for the recycling of waste. It has another advantage of being used as a fuel which is a scarce commodity. I may add that processes have been developed for conversion of solid waste from apple into poultry feed, bakers' yeast, enzyme production, pectin extraction etc. However, most of the technologies for the waste utilization are developed at the lab scale so they have to be scaled up for commercial exploitation by the industry. Since the waste is a source of pollution; it has to be treated before discharging into the environment.

Thus, from the resource utilization point of view, whatever material can be extracted from the waste should be recovered before the disposal of the waste to meet the requirements of pollution control agencies. The future Research and Development should be focused on the bioconversion of the waste into animal feed, solvents, microbial colours, flavours, bakery products and as an enrichment of food materials. Since the waste has potential to produce several value added products like biocolours, bioflavours, essential oils, essences, dietary fibres, starch, neutraceuticals etc., extensive research efforts should be engineered in the universities and research institutions to meet this objective. For this purpose MNCs could also be involved to draw plans for the utilization of fruit and vegetable waste in food, feed, pharmaceutical and biochemical industries, which avenues remain unexploited so far. Lack of integrated waste management technology at the industrial scale is the biggest hurdle.

The regulatory agencies can act as a catalyst in developing different processes for the utilization and management of waste arising out of processing industries. In this regard, the common food act being drafted by the central government could also include some sort of incentive to the industry which efficiently makes use of the solid waste for recovery of value added products. The planners should invest more on Research & Development on waste utilization if we have to protect our beautiful planet from pollution and environmental hazards which is endangering the very existence of biological system. In brief, we have to think clean, act clean, and develop eco-friendly processes and technologies to prevent the wastage of natural resources to the greatest extent. Finally the points on which future strategy of fruits and vegetable waste management can be developed are listed below:

- Improving indigenous technical knowledge for utilization of fruits and vegetable waste.
- Research on microbiology and biotechnology for recycling the waste and production of new useful products.
- Engineering technology needed for effective separation of fruit and vegetable waste so that the entire waste is reused as best as possible.
- Use such techniques which generate no or less quantity of waste (dry casting technology/enzyme technology for juice processing).
- Recover maximum useful materials (pectin from apple pomace, lactose from whey)
- Convert the waste into useful products (ethanol from fruit waste, citric acid from pomace, enzyme from wheat bran, animal feed from waste)
- Use the waste as substrate for production of valuable substances (SSF of waste for mushroom production, single cell protein, pigment production)
- The waste material should get first preference for food/feed related substances, followed by biogas.
- Waste water treatment should be the last strategy to meet the requirement of pollution control agencies.

EFFLUENT AND SOLID WASTE MANAGEMENT FROM FRUITS AND VEGETABLES PROCESSING PLANTS

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Traditionally, effluent arising from fruits and vegetable processing plants has been subjected to removal of particulate matter, oxidation of dissolved biological (BOD) and chemical (COD) entities and in certain instances de-odorization to meet State Pollution Control Board (SPCB) norms for suitability of treated water for irrigation. However, this process has been capital intensive, energy intensive and still couldn't meet SPCB norms in wide variety of treated effluents. Besides, this process generated hazardous sludge to be disposed at pre designated sites as per SPCB rules. During this period, R & D demonstrated that wasteful use of electricity for BOD/COD reduction could be avoided, release of green-house gases (predominantly CO_2) could be minimized and industrially useful biogas could be generated by anaerobic process, without increasing either cost of treatment or ease of operations. Utility of this process is explored at Jain Irrigation Systems Ltd (JISL), with several technological 'firsts' incorporated to simultaneously treat suspended solids. Efforts made in this direction constitute the theme of this article.

Effluent: Daily about 1000 m^3 effluent from fruits processing plant and 500 m^3 effluent from onion dehydration plant was treated anaerobically. Its BOD was around 1300 ± 200 mg/lit, COD 2200 ± 200 mg/lit and contained about 5 % suspended solids of 0.2 -1.0 cm diameter (pH 5.0 ± 0.5).

Inoculum: In a pilot plant of 85 m^3/day capacity, effluent and solid waste from onion dehydration plant and fruit processing plant was treated anaerobically using fresh cattle dung as inoculum. The effluent slurry arising out of this plant constituted inoculum for the preparation of active sludge for treatment in primary digester (500 m^3).

Digesters: The primary digester (500 m^3) and secondary digester (1500 m^3) treated 1500 m^3 effluent per day. The biogas liberated was collected in an adjoining gas holding tank (60 m^3). Broadly, the hardware was designed in such a way that treated effluent would reduce 90% BOD/COD load. The technological details remain proprietary information of JISL.

Treated effluent: It was monitored for SPCB norms and used for irrigation of JISL's horticultural R & D farm.

Analysis of biogas: Methane measurements were done using digital methanometer (Technovision, Mumbai).

In many places, industrial effluent is treated by Upflow Anaerobic Sludge Blanket (UASB) system. However, in the present instance, this system was modified to address the presence of about 5 mt onion solids per day. It operates by gentle stirring, which mixes the contents of digester continuously, traps suspended particulate matter and activates biomass so as to achieve twin objectives of treating solid waste and effluent concurrently and at the same time produce more biogas due to hydrolysis of suspended matter.

Such system is anticipated to reduce BOD load to 175 ± 25 mg/lit and COD 250 ± 50 mg/lit and produce 1200-1500 m3 biogas per day. Its composition would be minimally 60-65 % CH_4, about 30-35 % CO_2 and traces of H_2S as well as NH_3. The CH_4 content of biogas has scope for improvement to 80 % by fortification with microbes specialized in amylolysis, proteolysis and methanogenosis. Its calorific value would range between 4500 - 5000 kcal/m^3.

The operational aspects of this system are depicted in Fig. 1.

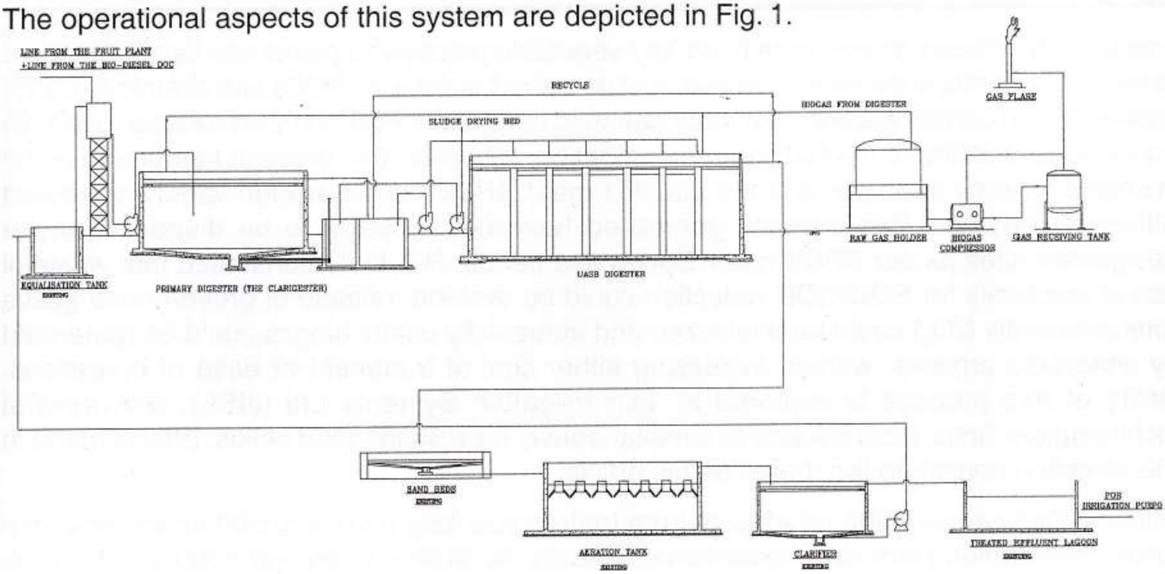

Fig. 1. Flowchart depicting effluent treatment for biogas generation.

It is assumed that the above system operates for 330 days per annum. It would generate biogas adequate enough to meet pay-back of Rs. 80 lacs involved in this system. Such pay-back is derived on the basis of gas generated as a replacement to furnace oil, which is presently used for generating steam for onion dehydration. The above pay-back period doesn't take into consideration several other side-benefits which will accrue. For example, production of organic manure enriched in its nitrogen content.

In the above system, treatment to voluminous discharge is considered. On the similar lines, solid waste management at pilot scale (85 m^3) is initiated. The company generates more than 7000 mt of mango processing waste (mango stone and peels), 800 mt banana processing waste, 150 mt guava processing waste and almost equal amount generated by each aonla, tomato and papaya processing. The waste is shredded to small (0.5-3.0 cm) pieces and suspended in the above effluent fortified with 5 % (v/v) cattle dung as an inoculum. This system is working since last two years and has successfully replaced the use of LPG cylinders in 5 places, equivalent to minimally 6-7 cylinders per day.

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EVALUATING THE MANURIAL VALUE OF IRRADIATED SEWAGE SLUDGE FOR SOIL PROPERTIES AND YIELDS OF CARROT

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To evaluate the superiority of the gamma irradiated sludge, if any, for its suitability as manure in terms of plant growth and yield and presence of excess heavy metals in soil, a field experiments were carried out with carrot crop in rabi season of year 2003-04. Treatments consisted of three sources of manures (FYM, Irradiated Sewage Sludge and non-irradiated Sewage Sludge) each at three different levels (5, 10 and 15 t ha-1). The growth parameters (plant stand, root length, root girth) and yield of carrot was not significantly influenced by the three sources of manures as well as their different levels. The results point out that the sewage sludge materials were as good as the conventional FYM. FYM contained exceptionally high nitrogen content (1.8 %) No harmful effect of sludge due to any toxic substance was noticed. Values for EC, pH, organic carbon, total N, available P and K, metallic micronutrients (Zn, Mn, Fe, Cu) and heavy metals (Ni, Cd, Pb, Cr, Co) indicated no adverse effect on soil properties. There was no significant difference between irradiated and non-irradiated sludge treatments in any of the measured soil properties. In fact, some favourable effect was noticed in certain nutrient concentration. Concentration of heavy metals in soil and plant were within the prescribed limit and no significant increase was consistently noted.

The agricultural use of sludge provides an alternative to other disposal options, such as river or ocean dumping and landfill. Sewage sludge generated in wastewater treatment plants through conventional primary and secondary treatment processes generally undergoes further stabilization before its disposal on land. Several methods are available, including anaerobic digestion, composting and thermal disinfection to make the sludge biologically and chemically safe.

Recently, the use of ionizing radiation has proven to be effective in hygienization of sewage sludge. Gamma irradiation of sewage sludge, in addition to removing harmful pathogenic organisms, can lead to changes in physical and chemical properties. An irradiation facility (SHRI - Sludge Hygienisation Research Irradiator) is installed by BARC at Vadodara to treat up to 110 cu. m day-1 sewage sludge emanating from 20 million litres of sewage, which is half of the sewage generated every day in the city of Vadodara. The sewage sludge is irradiated with gamma rays (dose of 3 kGy) to disinfect the pathogens. It has about 1.4 % N, 1.4 % P_2O_5 and 0.2 % K_2O on oven-dry basis. On drying, it could be powdered easily. It does not have bad odour. Hence it has a potential to serve as manure. The study aims to assess the quality of the manure with respect to heavy metals.

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MATERIALS AND METHODS

Field experiment was carried out during Rabi season of year 2003-2004 at ECFP farm, AAU, Anand with carrot (variety : Pusa Kesar). Irradiated and non-irradiated sewage sludge was incorporated into soil to 15-20 cm depth. The treatments were laid out in a factorial randomized complete block design. Each block having nine treatments and each treatment was replicated three times. Treatments consisted of three source of manures (S_1 : FYM, S_2 : Irradiated sewage sludge and S_3 : Non-irradiated sewage sludge) each at three different levels (L_1: 5 t ha^{-1}, L_2 : 10 t ha^{-1} and L_3 : 15 t ha^{-1}).

Carrot roots were collected as they ripened and were weighed for yield determination. Growth parameters such as plant stand, Girth and length of produces were also measured. Three plant samples from net plot were collected for its edible part and leaves analysis. Soil samples (0-20 cm depth) were collected at the end of the growing season. The samples were air-dried, crushed to pass through a 2 mm sieve and stored for analysis. Plant and soil samples were analyzed using standard methods (Jackson, 1973). The data were subjected to analysis of variance using FRBD statistical analysis package.

RESULTS AND DISCUSSION

The sewage sludge had a pH close to neutral, high organic matter, high total N content and high content of micronutrient in bio-available forms (Table-1). Difference in chemical properties between irradiated and non-irradiated sludge were not significant. The FYM used was of exceptionally good quality with 2 % N content. The soil of experiment site is alluvial in nature, texture ranged from loamy sand to sandy loam and locally known as *'Goradu'*. The N content was low, P and K content were medium.

Table 1. Chemical characteristics of manures

Characteristics	FYM	Irradiated sewage sludge	Non-irradiated sewage sludge
pH (1:2.5)	6.42	6.81	6.64
Nitrogen (%)	1.80	2.30	2.00
P_2O5 (%)	0.48	0.19	0.23
K_2O (%)	0.26	0.15	0.18
Org. matter (%)	35.56	37.65	42.57
Zn (ppm)	11.05	50.16	49.08
Mn (ppm)	15.00	38.22	25.53
Fe (ppm)	3300.00	7130.00	6807.00
Cu (ppm)	1.41	1.91	2.19
Ni (ppm)	6.96	10.20	12.23
Cd (ppm)	0.95	1.06	1.45
Pb (ppm)	9.07	14.25	14.00
Co (ppm)	4.18	6.20	6.40

Table 2. Influence of irradiated sewage sludge on yield and growth parameters of carrot

Treatment	Yield ($Q\ ha^{-1}$)	Plant stand (No. $plot^{-1}$)	Root length (cm)	Root girth (cm)
Source of manures (S)				
S_1	128.18	486.89	23.18	12.82
S_2	133.50	518.00	25.46	14.20
S_3	128.48	512.67	24.75	13.34
CD (5 %)	NS	NS	NS	NS
Levels of manure (L)				
L_1	124.75	493.44	23.81	12.84
L_2	126.25	512.44	24.29	13.76
L_3	139.14	511.97	25.29	13.76
CD (5 %)	NS	NS	NS	NS
S x L	NS	NS	NS	NS
CV %	15.78	7.10	10.64	7.58

A. Yield and growth parameters

The yield of carrot was not significantly influenced by the various sources of manure as well as their different rates (Table-2). Fauziah and Rosenani (1999) obtained non-significant trend for corn yield due to application of irradiated and non-irradiated sewage sludge. Contrary to this, Motaium and Badawy (1999) reported higher tomato yields due to application of irradiated sewage sludge. The results of the growth parameters (Table-3) viz., plant stand, root length, root girth also did not statistically vary and supported the yield data as discussed above. The results point out that the sewage sludge materials were as good as the conventional FYM. The FYM used was of exceptionally good quality with 2 % N content.

B. Soil and plant analysis

Electrical conductivity (total salts), pH, total N, available P and K, available metallic micronutrients (Zn, Mn, Fe, Cu) and available heavy metals (Ni, Cd, Pb, Co) were presented in Table 4 & 5. It was evident that the sludge materials increased available P and K significantly over that of FYM. Available Mn and Fe increased with increase in the rate of application of manure. Other parameters were not influenced significantly.

Concentrations of major nutrients (N, P and K), metallic micronutrients (Fe, Mn, Zn, Cu) and heavy metals (Ni, Cd, Pb, Co) in carrot root and leaves are reported in Table 6 and 7. Iron content was higher when the sludge (S_2 and S_3) was applied. Other elements did not vary significantly in their concentrations. Athalye *et al.* (1999) observed that the application of irradiated sewage sludge to soil @ 1 to 8 t ha^{-1} maintained N, P, K concentrations in plants and showed no signs of attaining enhanced levels of heavy metals due to repeated addition of sludges. Interactions S x L for N and Co in carrot roots and N and Mn in carrot leaves were significant (Table 8 & 9). With higher levels of Manure, increase in N content was seen.

Table 3. Influence of irradiated sewage sludge applied to carrot crop on soil EC, pH and major nutrients

Treatment	Total Nitrogen (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Organic carbon (%)	pH (1:2.5)	EC (1:2.5) (dS m^{-1})
Source of manures (S)						
S_1	0.028	62.48	231.2	0.33	7.76	0.13
S_2	0.033	89.40	251.5	0.39	7.81	0.14
S_3	0.030	80.12	216.8	0.35	7.76	0.14
CD (5 %)	NS	9.52	17.0	NS	NS	NS
Levels of manure (L)						
L_1	0.026	77.30	219.2	0.31	7.73	0.13
L_2	0.033	80.14	220.4	0.39	7.83	0.14
L_3	0.033	84.56	259.9	0.38	7.77	0.14
CD (5 %)	NS	NS	17.03	0.05	0.07	NS
S x L	NS	NS	NS	NS	0.13	NS
CV %	14.71	11.80	7.31	14.61	0.93	10.18

Table 4. Influence of irradiated sewage sludge applied to carrot crop on soil metallic micronutrients and heavy metals

Treatment	DTPA extractable micronutrients (ppm)				DTPA extractable heavy metals (ppm)			
	Zn	Mn	Fe	Cu	Ni	Cd	Pb	Co
Source of manures (S)								
S_1	1.49	45.86	18.60	1.87	0.58	0.13	0.93	0.46
S_2	1.64	42.24	18.25	1.84	0.83	0.11	1.08	0.48
S_3	1.63	37.77	19.77	1.92	0.73	0.14	0.89	0.44
CD (5 %)	NS	NS	NS	NS	NS	NS	NS	NS
Levels of manure (L)								
L_1	1.50	38.08	15.80	1.80	0.71	0.12	0.82	0.45
L_2	1.59	38.99	18.00	1.78	0.69	0.13	0.93	0.46
L_3	1.67	48.79	22.82	2.04	0.73	0.13	1.15	0.46
CD (5 %)	NS	6.45	2.79	NS	NS	NS	NS	NS
S x L	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9.58	15.43	14.84	16.64	20.65	22.87	20.79	16.56

Table 6. Influence irradiated sewage sludge of Sludge on chemical properties of carrot root

Treat.	Major nutrients (%)			Micronutrients (ppm)				Heavy metals (ppm)			
	N	P	K	Zn	Mn	Fe	Cu	Ni	Cd	Pb	Co
Source of manures (S)											
S_1	0.56	0.72	1.84	15.63	30.38	259.18	16.95	6.17	2.48	4.72	1.62
S_2	0.67	0.66	1.84	17.62	23.72	309.19	18.87	7.08	2.64	5.72	1.72
S_3	0.67	0.67	1.87	17.11	26.93	316.09	16.48	5.92	2.10	5.39	1.50
CD (5 %)	0.09	NS	NS	NS	NS	72.41	NS	NS	NS	NS	NS
Levels of manure (L)											
L_1	0.60	0.62	1.73	15.68	25.61	343.80	18.30	6.08	2.30	5.22	1.45
L_2	0.61	0.70	1.85	16.92	23.03	247.08	17.19	7.50	2.27	5.11	1.39
L_3	0.69	0.75	1.96	17.76	32.39	285.62	16.81	5.58	2.64	5.50	2.00
CD (5 %)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.49
S x L	0.16	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.85
CV %	14.5	19.5	20.1	18.4	2.7	24.8	27.9	20.0	19.1	19.9	30.4

Table 7. Influence of irradiated sewage sludge on chemical properties of carrot leaves

Treat.	Major nutrients (%)			Micronutrients (ppm)				Heavy metals (ppm)			
	N	P	K	Zn	Mn	Fe	Cu	Ni	Cd	Pb	Co
Source of manures (S)											
S_1	0.95	0.47	1.02	40.49	180.01	1371	26.61	18.67	2.34	14.50	8.83
S_2	1.01	0.49	1.06	45.04	195.09	1435	28.49	15.83	2.46	16.56	9.92
S_3	0.97	0.50	0.99	41.64	190.16	1300	424.62	18.50	2.39	15.7	10.08
CD (5 %)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of manure (L)											
L_1	0.92	0.50	0.86	38.08	184.23	1278	26.69	17.75	2.22	15.72	9.50
L_2	0.99	0.47	0.98	43.34	192.2	1367	25.18	17.00	2.40	15.06	9.67
L_3	1.02	0.50	1.24	45.74	188.90	1460	28.25	18.25	2.57	16.00	9.67
CD (5 %)	NS	NS	0.30	NS	NS	NS	NS	NS	NS	NS	NS
S x L	0.23	NS	NS	NS	59.26	NS	NS	NS	NS	NS	NS
CV %	13.50	15.59	29.09	25.65	18.22	19.84	21.29	16.54	20.56	15.40	0.00

Table 8. Interaction effect of manures and its levels on nitrogen (%) and DTPA extractable cobalt (ppm) contents of carrot root

Level of manure (L)	Nitrogen (%) Source of manure (S)			Co (ppm) Source of manure (S)		
	S_1	S_2	S_3	S_1	S_2	S_3
L_1	0.44	0.64	0.72	1.35	1.67	1.33
L_2	0.61	0.62	0.61	1.02	1.33	1.83
L_3	0.64	0.76	0.67	2.50	2.17	1.93
CD (5 %)	0.016	0.85				

Table 9: Interaction effect of manures and its levels on nitrogen (%) and DTPA extractable Mn (ppm) contents of carrot leaves

Level of manure (L)	Nitrogen (%) Source of manure (S)			Co (ppm) Source of manure (S)		
	S_1	S_2	S_3	S_1	S_2	S_3
L_1	0.96	0.93	0.87	149.93	188.10	201.98
L_2	1.09	0.89	1.00	168.82	210.48	205.97
L_3	0.79	1.22	1.05	233.95	177.78	158.75
CD (5 %)	0.23			59.26		

CONCLUSION

The yield data of carrot root point out that the sewage sludge materials were as good as the conventional FYM. The FYM used was of exceptionally good quality with 2 % N content. No harmful effect of sludge due to any toxic substance was noticed. It is enough to apply 5 t ha^{-1} dose. The nutrient concentrations in soil and plant also indicated no adverse effect. In fact some favourable effect was noticed in certain nutrient concentration. Concentration of heavy metals in soil and plant were within the prescribed limit and no significant increase was consistently noted.

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UTILIZATION OF AGRICULTURAL AND INDUSTRIAL WASTE AS A SOURCE OF NUTRIENTS

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The greatest challenge in the 21st century is to feed the ever-increasing population. Even though the use of mineral fertilizers provides the way to achieve this, the limitation in the availability of fossil fuel creates energy crisis and makes the cost of fertilizers high. The present gap of about 10 Mt of NPK is likely to widened in coming years which necessitates the recycling of nutrients by all alternate means. The ample availability of organic wastes from agricultural residues and industrial liquid as well as solid wastes have tremendous potential to provide nutrients to the soil, if properly processed and utilized by converting into value added organic manure / compost by adopting suitable biodegradation process and technology. However, the process towards sustainable agricultural production system should include regular monitoring for soil-plant health and putting minimum risk to the environmental pollution.

The most pressing social demand today is to sustainably increase the productivity of production system in agriculture. Presently, use of inorganic fertilizers alone in the intensive cropping system creates infertility and unfavourable soil physical conditions and biological system. Soil health is deteriorating year after year. It can be overcome by use of organic along with mineral fertilizers for health and sustainable crop production. Complementary use of available renewable sources of plant nutrients like recycling of organic wastes and biofertilizers along with fertilizers is of great importance.

The wastes are of different kinds including domestics wastes, city garbage, sewage effluents and sludge, vegetable waste, crop residue, industrial effluents and sludge etc., which affect the environment and the harmonious relationship between the biotic and abiotic components of the ecosystem. The current aim of sustainable agriculture is to develop farming system that are productive and profitable, conserve the natural resource base, protect the environment and enhance health and safety in long term perspective. Low input farming system seek to minimize the use of external inputs like fertilizers and avoid pollution of surface and ground water and lower the production cost.

Presently, India consumes about 17.8 million tonnes (Mt) of fertilizer per annum and more than 65 per cent of it is nitrogenous fertilizer (FAI, 2000-01). In the present scenario, removal of NPK from soil in India was about 28 Mt as against the addition of 18 Mt thus there is a net negative balance of 10 Mt and this has to be replenished by all means. Further, the total estimate of current need of all micronutrients is 1,10,523 tonnes per year. This would increase to 1,90,227 tonnes per year by the year 2025 AD. Only about 80,000 tonnes of all types of micronutrients fertilizers are produced including micronutrient mixture grades (Prasad, 1999). This indicates that there is a big gap between need and supply of micronutrients to soil. The estimate on removal of the micronutrients by crops in Gujarat also pointed out needs for balanced fertilization (Patel, 2001). The deficit can be met only by integrated use of mineral fertilizers with agricultural and industrial wastes as a source of nutrients. The incorporation of agricultural wastes and city wastes in soil may serve as a direct source of major and micronutrients and also helps in mobilizing the native nutrients available to plants. The organic wastes from different sources could be recycled, reprocessed and put to productive use.

AGRICULTURAL AND AGRO-INDUSTRIES WASTE

The availability of total agricultural wastes from major crops has been estimated to be 493 Mt annually in the country. However, only about 39 per cent are utilized for the purpose of organic recycling in India. The total amount of N, P_2O_5 and K_2O recovered in the residue comes approximately to 2.7, 1.2 and 5.3 Mt, respectively (Beri, 2002).

All the available organic waste materials can be converted into value added organic manure/ compost by adopting suitable biodegradation process and technology. The wide C/N ratio materials are to be converted to narrow C/N ratio materials for utilization as manure by introducing appropriate microorganisms, inorganics, additives and moisture.

Composting Farm Waste

Composting is carried out in pits by filling the crop residues of farm wastes and cowdung slurry is sprinkled to enhance the process of composting. Bone meal/rock phosphate are added to improve the nutrient availability and conserve N loss. Vermicompost is another useful technique for recycling of organic wastes. It has been reported to be beneficial in crop production. Patel and Patel (1997) reported saving of 25 % NPK by using vermicompost in forage production of maize. However, vermicompost alone has not been found beneficial but its integration with NPK proved to be better in sugarcane production (Lad *et al.* 1997).

Enrichment of FYM with $FeSO_4$, $ZnSO_4$ and biofertilizers can further increase the quality and improve manurial value of the enriched FYM through composting. The Zn application through enriched organics could be a better way for management of micronutrient stress to increase crop yields under maize-wheat cropping sequence as well as to reduce chemical load thereby improvement in soil quality (Rathod *et al.* 2005). Similarly, Meena *et al.* (2005) suggested the importance and practical utility of FYM enrichment with Zn and Fe for managing micronutrient stress and increase crop productivity of the soil in mustard.

Biogas

Biogas is one of the potential renewable source of energy. Instead of directly using the animal dung for composting, it can be used for production of biogas by feeding through biogas plant. From the 1800 Mt of animal dung per annum in India even if two-third dung is used for biogas generation it is expected to yield biogas not less than 120 million m^3 / day. In addition the manure produced would be about 440 Mt per year which is equivalent to 2.90 Mt of N, 2.75 Mt of P_2O_5 and 1.89 Mt of K_2O (Ramaswami, 1999).

Sugar and Distillery Industrial Waste

Among the agro industry wastes, sugarcane industry wastes are amply available. Pressmud is very commonly used as an amendment. The pressmud from sulphitation process has been found more beneficial due to S as well as micronutrient contents. The enhancement in manurial value of pressmud due to incorporation with Azotobacter has been reported, which also reduced the pressmud application rate in sugarcane Banger, (1998). Before utilizing the distillery effluent for crop production, it can be efficiency utilized for methane gas generation by anaerobic fermentation process utilizing the methanogenic bacteria. The methane gas generated can be utilized in the factory itself for its power requirement.

Biocompost is a manure from waste such as pressmud and distillery effluent. It is humus-rich organic manure prepared by mixing pressmud and distillery effluent in the ratio of 1:2.5. Bacterial culture which enables quick bioconversion of organics is sprayed on the pressmud and mixed thoroughly. Enrichment of biocompost with rock phosphate, $FeSO_4$, $ZnSO_4$ and biofertilizers can further increase the quantity and improve value of the compost.

The release of bagasse as a by-product from the sugar industry is about 30 per cent of the weight of cane crushed. From the sugar factories alone, there is a possibility of collecting about 45 Mt of bagasse. The bagasse can be effectively utilized as a raw material for the paper and pulp industries instead of using as a fuel material. By this was, the cutting of forest trees wealth can be protected. Sugar factories in India have the potential to produce over 400 MWs of power in this manner.

Another type of waste material obtained from sugarcane is sugarcane trash. Instead of burning the sugarcane trash in the field, it can be efficiently composted by adopting bioconersion technology and used as organic manure.

Poultry Dropping

Poultry farm waste like poultry droppings are generated enormously and are increasing year after year. When it is used as manure as fresh it affect the land/crop by creating local alkalinity. When used after stacking for a considerable period, the precious N nutrient present in the poultry dropping would be lost as volatile ammonia. Therefore, it is always better to preserve the nutrient by mixing with suitable amendments and appropriate microbes. A nutrient rich poultry dropping compost can be prepared which is found to give better performance for field crops.

URBAN AND INDUSTRIAL WASTE

Sewage Water Use in Field Crops

The domestic wastewater/sewage irrigation is an age old practice in India. The first farm for wastewater irrigation was started in Ahmedabad during 1895. As per survey report of GPCB (1995), Ahmedabad city alone generate as much as 742 million liters per day of sewage. There were 216 wastewater irrigated farms in the country covering 10,693 ha area and utilizing more than 40 % of the available wastewater of the country (1971 Statistic Report). These farms receive 75 % of untreated wastewater and 25 % treated (primary and/or secondary) wastewater and are disposal oriented rather than utilization. In general, sewage water generated in India contains more than 90 % water. The solid portion contains 40-50% organics, 30 - 40 % inert material, 10 - 15 % bi-resistant organics and 5-8% miscellaneous substances on oven dry basis (Olinya *et al.*, 1998). There is an increase in hydraulic and nutrient loading above the assimilation capacity of soil- plant system (Maliwal, 2005).

Nutrient supplying potential of sewage is directly related to the composition, which in turn depends on the extent of industrialization and urbanization of the area from where sewage is generated. It contains good amount of essential plant nutrients viz., N, P, K and micronutrients like Zn, Cu, Fe and Mn (Singh and Kansal, 1985; Sharma and Kansal, 1986; Maiti *et al.*, 1992). It is estimated that through 5 irrigations, each of 7.5 cm, untreated sewage water is enough to meet macro and micronutrients requirement of crop. It is further estimated that sewage water in India have a potential to contribute 7, 43, 370 tonnes of nutrients per year (Maliwal, 2005).

The impact of sewage water irrigation on soil-plant system was studied in cabbage / cauliflower-okra-sweet corn crop sequences (Anon., 2004). The study revealed the usefulness of sewage water which not only contained heavy metals but useful nutrients also. The sole use of sewage or combined with tube well water (1:1) showed reduction in chemical fertilizer (N) application by 25 per cent and significantly increased crop yields by 8 to 9 per cent in cauliflower and sweet corn. The irrigation with sewage water and tube well water in 1:1 proportion has been found more advantageous for practicing irrigation where the good quality water is not available in required quantity (Anon., 2004).

However, only use of sewage water might cause build up of heavy metals especially of Cu over years as observed by Patel *et al.* (2005a) in sewage irrigated farm near Ahmedabad. The copper application on soils irrigated with effluent / sewage water having high Cu is likely to cause toxicity to sensitive crops. Such toxic effects could be alleviated by liberal application of organic amendment like FYM.

Use of Sewage Water in Forestry

India has a geographical area of 328.05 million hectares, 50 per cent (161 million hectares) is cultivated and less than 20 per cent is under forest. The total water potential of India is about 400 million hectare meter out of which only 50 per cent can be put to potential use such as domestic, industrial and agricultural consumption. Out of total cultivated area only 50 per cent is under irrigation due to scarcity of water. The available domestic waste water can be efficiently used for agriculture and forestry development. Swage being a rich source of nutrients can be used for the development of forestry to meet the increasing demand of biomass. Forest land provides an area for recycling agricultural waste. Wastewater effluent applied to forest species over extended period of time with good nutrient removal efficiency and minimal impact on surface or ground water (Maliwal, 2005).

For safe utilization of irrigation and nutrient potential of waste water in forestry, the following points must be considered:

- Sewage should not stagnate so as to avoid foul smell and breeding ground for mosquitoes.
- It should not percolate down to contaminate groundwater.
- It should not harm soil health.
- Vegetation raised with sewage should not be directly consumed by human beings.
- It should be an economical system generating employment and revenue.

The "Karnal Technology" has potential to eliminated pollution by utilizing the irrigation and nutrient potential of such waste waters, right in the area of their production (Chhabra, 1987).

Industrial Effluents

Due to increase in industrialization, the economical status of people through large scale employment as well as efficient utilization of agricultural byproducts, yet these beneficial effect have been coupled with hazards of environmental pollution by discharge of industrial wastes (sludge and wastewater) in large volume into the soil body. Along with soil, the ground water has also been polluted to a level of human health hazard. The productivity of crops was below the normal productivity mainly due to development of salinity besides ill effects of effluents usd in agriculture (Patel *et al.*, 2005b).

However, all effluents are not pollutants. Many may be used as a irrigation water. Some may be used for its fertilizer nutrient value. Efforts have been made by many workers (Bahirat *et al.*, 1989; Zalawadia and Raman, 1994; Zalawadia *et al.,* 1997 and Maliwal, 2002-03) for using such by products/wastewater for partial substitution of inorganic fertilizer and improving soil productivity. Use of such waters for irrigation where the ISI standards are more liberal than letting them out to upon surface water may reduce the environmental pollution. For evolving practically feasible and eco-friendly management package for wastewaters, it is prerequisite to know their chemical composition. Once the chemical composition of a given wastewater is known, it can easily be classified using standard criteria and its suitability for irrigation purpose and/or its disposal mode can be designed (Maliwal, 2005).

The composition of wastewater varies from industry to industry, process used, raw material used, nature and quality of input chemicals and quality of raw water. The wastewater as well as solids are either released in the nearby river water or dumped in the open space. Gujarat has different types of industries viz., textile, paper, sugar factory, distilleries, chemical factory, dyes, electroplating, rubber, oil, dairy, rice mills, plastic, fertilizers, petro-chemicals, oil refinery, pharmaceuticals, gases etc. and the effluent produced by them are of different nature. An effluent quality survey from different industries / sites of Central Gujarat (Vadodara and Bharuch districts) and South Gujarat (Surat, Navsari and Valsad districts) indicated that sugar and paper factories effluents pose less problems (Raman and Zalawadia, 1997) for use as irrigation water. The industries located in other parts viz., Vadodara, Ahmedabad, Kheda, Bharuch and Ankleshwar of Gujarat (Patel *et al.,* 2003) have also been surveyed and samples analysed for the characteristics of industrial effluents individually and combined effluents (Patel *et al.*, 2002). The combined effluent water of various industries have been found unsafe for irrigation. Theses waters need proper treatment before its disposal to stream / channel. (Anon., 2002).

The irrigation with effluent caused contamination of soils with heavy metals viz., Cd, Cr, Pb, Ni and Co mainly in root zone layer (0-30 cm), plants and ground water all along the effluent channel; and the contamination of soil and ground water was extended up to 2.0 km on left side of the channel (Patel *et al.*, 2004; Maliwal *et al.*, 2004). The heavy metals were found more concentrated in roots followed by leaves, stems and grains / edible parts of crops grown in the areas. Although, their contents in edible portion were low, their presence is a matter of concern from health point of view (Anon., 2004). The suitable crop / plant species could be grown for safe utilization of effluents in agriculture.

The three years study on impact of industrial effluents in pearlmillet-cabbage-sorghum (fodder) system on farmer's field at Umaraya revealed that the use of untreated effluents for irrigation was found more harmful to sorghum and pearlmillet than cabbage grown. The treated effluent and its alternate use with tube well water could reduce the harmful effect of the toxic elements on crop growth. The use of treated mix industrial effluent with alternate use of tube well water (1:1) was found more beneficial and increased cabbage head yield by 42 per cent over tube well water. It was also beneficial for sorghum and pearlmillet. However, the use of effluents water has showed accumulation of the toxic elements besides increasing salinity in the soil after three years; and the increase was more in only use of untreated effluents. Thus, the use of treated effluent in combination with available tube well water (1:1) for irrigation could be practiced under regular monitoring for soil health where availability of good quality irrigation water is scarce (Anon., 2004).

The effluent could be purified with bioremediation techniques like use of Pseudomonas sp. and locally isolated fungi. Low cost locally available adsorbents viz., fly ash, drumstick powder, FYM, activated charcoal, saw dust, paddy straw etc. could also be used for removal of heavy metals from the effluents. Further, locally available aquatic weeds viz., Eichhornia crassipes, Ipomea aquatica and Hydrilla have also been found more effective for removal of the metals viz., Cr and Ni in mix industrial effluent. The accumulation of absorbed Cr and Ni in the plant was found in the order of roots > leaves > stem for *Eichhornia crassipes* and *Ipomea aquatica* (Anon., 2004).

Solid Wastes

The domestic and industrial sewage sludge are also potential sources of trace metals. The variable trace metal composition of sludge of some major cities reflects that most of this sewage is the mixture of domestic and industrial wastes. Metal contents in sludge vary greatly with the nature of the sewage generating industries, type of raw materials and processes used in the different industries which are responsible for variability in contents of heavy metals in sewage sludge (Rajukar and Kulkarani, 1997, Anon., 2004). A comparison of metal contents in sludge with permissible limits given by commissions of European community revealed that all the potentially toxic elements were within permissible limits with exceptions of Zn and Hg.

The solid waste is a mixture of several items having different physical properties with a daily generation rate of about 500 gm per individual. The waste includes combustible, recyclable and inert materials. Paper, cloth, wrapper sheets and board can be kept separately for recycling. By following appropriate bioconversion technology the period of composting can be reduced considerably. There are reports which indicate an increase in organic carbon and infiltration rate and decrease in bulk density of soil due to application of sludge. However, high rate of sludge application may be harmful due to toxic effects of heavy metals in a long run. Incorporating FYM or other agriculture waste mitigate such toxic effects of heavy metals (Patel and George, 2005).

The work on pressmud, fly ash and coir pith are carried out by different workers in the country. The oxalic acid industrial waste is highly acidic with considerable amount of organic carbon, it can be tried as an amendment for calcareous soils. The pressmud cake with its high organic content coupled with not so high C: N ratio can be useful as an organic amendment. Ferrochrome industry slag has very high chromium content and hence pollute the environment. Pressmud quality depends upon the processes used and pressmud produced through sulphitation processes seems to be better for manurial purpose.

Integrated Solid Waste Management

The complementary use of a variety of waste management practices is known as "Integrated Waste Management". Land filling and incineration are currently two major technological approaches for handling solid waste. Other techniques are also used in some combination with one or both of followings.

- Source reduction
- Recycling (including composting)
- Waste combustion with energy recovery
- Land filling

These techniques can be used together to handle solid waste economically while minimizing the environmental impact (Pande, 2004).

CONCLUSION

India is a country with a lot of natural resources. Many of the resources are not being fully utilized. The entire nutrient requirement for crop production can be obtained from proper bioconversion of wastes. This alone will give a clean and protected environment. There is a great potential and scope for eco-friendly management for sustainable agricultural production.

The gap in nutrients consumption and removal is likely to be increased by 2025-AD due to heavy depletion of nutrients as a result of intensive agriculture to meet the targets of food production. The demand for micronutrients would be more difficult to tackle compared to that of NPK fertilizers. However, agricultural and city wastes which are amply available are potential sources to meet the requirements of micronutrients by crops; if utilized with suitable technology.

The wastes can be utilized as direct incorporation or can be made available by composting. Composting is a better way to enhance the efficiency of nutrients utilization. The manurial value of compost can be further enhanced by enrichment with Zn or P or by inoculation with biogas slurry or useful microorganisms like *Azotobactor, P- solubilizers, Penicillium sp.* etc. City wastes viz., sewage water, mix industrial effluents and sludge are rich sources of major and micronutrients; but its use is largely confined in peri urban areas for production of vegetables. Waste water management through land application involves renovation of wastes, reuse of water and nutrients for biomass production, returns of minerals and waters to natural resources and recharge of surface and ground water. Waste water is also a potential source of heavy metals; therefore, its continuous use for irrigation should include regular monitoing to avoid contamination of soil-water plant system. They can be used safely with recommended treatments as a source of nutrients for higher crop production.

FUTURE NEEDS

- More and more organic wastes should be brought under residue management for recycling of nutrients.
- Need to develop technology of wastes recycling suitable to different agro-eco situations.

- Soil-Water-Plant samples of peri urban areas need to be regularly monitored to check contamination and develop database for accumulation rate as safe guards.
- Suitable technology needs to be developed for utilization of sewage water and sludge in agriculture with minimum risk of pollution.
- Studies on mitigating harmful effects of toxic elements need more attention.
- Crop genotypes need to be identified / explored which can sustain high level of polluting elements; and restricts the entry of toxicants into food chain.

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Recommendations of 30th IAUA convention on "Effective Agricultural Waste Management"

1. Treatment of city wastewater should be made mandatory for using it in agriculture and industrial wastewater and domestic sewage water should be segregated.

2. Treatment methods and the minimum standards of the use of sewage water need to be standardized as per soil, crop and weather condition.

3. A task force be constituted to compile information already available on various aspects in the use of sewage water in agriculture. The task force be asked to identify critical gap and researchable areas.

4. The convention also emphasized on very effective and selective use of biomass for energy generation. The exploitation of ratanjyot (Jatropha) for energy generation be made with care by growing it only on the degraded/ marginal lands.

5. About 50 million tones of fruits and vegetable waste that is currently available should be efficiently utilized for various value added products and areas of management of fruits and vegetable waste should be identified and prioritized. The convention further viewed an urgent need to increase awareness for this purpose. It was felt that more funds be allocated for research and development of horticultural crops to different SAUs. It was suggested to establish referral laboratories for monitoring and guiding the residues in fruits and vegetables to overcome the rejection of export consignment and health hazards and thus to avoid the wastage.

Recommendations from IAUA Events of 2005

Recommendations of 29th Convention held at CCS HAU, Hissar, on 12-13 January 2005

"Quality of Agricultural Education in the context of National and International Commitments"

1. ICAR should have a major role in regulatory planning, formulation of norms, accredition and integrated development of education and avoidable proliferation of the institutes. ICAR should have statutory powers. (GOI/ICAR).
2. Specific commitments covering education in GATS be made in consultation with stake holders before making commitments on commercialization of education and training which may pose risks to public sector education. (GOI/ICAR/SG).
3. Education as service has a huge global market. In this industry, students are consumers, teachers are service providers and institutions are organizers. GOI through extensive privatization, commercialization and deregulation should encourage this process in higher education. (GOI/ICAR).
4. In light of provisions included in GATS (I) affirm Public Sector Agricultural Education (PSAE) as a social good, since it influences lives of millions of small and marginal farmers.
5. Closely monitor the futuristic discussions/negotiations of safeguard Indian interest.
6. Create a discussion forum to play a proactive role to impress upon the importance of PSAE.
7. IAUA and ICAR should coordinate the work. (ICAR/IAUA/SAUs).
8. Education for entrepreneurship should be promoted. It should include changes in market place through change in education system.(ICAR/SAUs).
9. SAUs should sign exchange agreements with international and national institutions with cosmopolite outlook. (SAUs).
10. Our education system should have paradigm shift based on faculty-student model, ICT application in agricultural, education for professional farmers, education for competitiveness, education for executives, education for serving the poor, education for voluntary sector, education for human values and ethical conduct and education for educators. (ICAR/SAUs).

11. Outsourcing of faculty and networking among SAUs and national institute should be encouraged to prepare students for MNCs. (ICAR/SAUs/MNCs).

12. SAUs should have Think Tank, Task Force and WTO cell/agribusiness Centre.

13. We should have task force at national level to prepare ourselves for international. Negotiate, modernize and reorient mindset for capital investment. (GOI/ICAR/SAUs).

14. Mobility within and between NARs/SAUs/DUs networking and ICAR/SAUs participation of Ph.D. students in academic activities should be encouraged. (NARs/SAUs/DUs/ICAR).

15. India can be service provider in developing countries for helping HRD in Africa, Middle East etc. in that context, India should set up a consortium for logistic support. Exchange of students and faculty with foreign institutes should be institutionalized. (GOI, ICAR and SAUs).

16. International research should be more strategic in its application and we should move from commodity centre to system approach, disciplinary to inter-disciplinary research, combine traditional knowledge with modern science and bring in right balance between national and international agenda. (ICAR and SAUs).

17. We should adopt quality improvement as a comprehensive international goal, develop appropriate learning environment, establish educational technology and establish educational technology and establish quality circles for total quality management. Improvement in quality should be viewed in context of measurable parameters like accountability, creativity, leadership, appreciation, team work. (ICAR and SAUs).

18. A uniform work load system for teachers/scientists/extension workers should be followed in all SAUs. (SAUs).

19. Changing technologies and globalization requires holistic approach to cater to quality in agricultural education vis-à-vis international commitments, food security and frontier sciences, i.e. biotechnology, remote sensing, I.T. connectivity, etc. to ultimately benefit our rural people. (SAUs).

20. A draft proposal on accountability in SAUs be prepared by ICAR for uniform measure of accountability and this be debated by SAUs for consensus. (Action: ICAR & SAUs).

Recommendations of Brain Storming Session held at IVRI, Bangalore Campus during 17th - 18th August 2005

"Distance Education In Agriculture"

1. There is general consensus that SAUs, DUs and CAU should not award formal degrees through ODEL in agriculture and allied disciplines at present and instead focus on catering to societal needs on demand driven vocational, entrepreneurial education and continued educational programmes for farmers, extension workers, rural youth and capacity building of agricultural graduates and faculty using ODEL. (Action: SAUs/DUs/CAU)
2. As a first step, in capacity building on ODEL activities and programmes at SAUs, each university may identify a Nodal Officer to eventually establish a Co-ordinating Cell on Distance Education. ICAR should be approached for funding under National Agricultural Innovation Project (NAIP) for establishment of Distance Education Cell at all SAUs and CAU. (Action: SAU/CAU)
3. Considering the Paucity of Specialized cadre of Animal Husbandry and Veterinary extension workers to promote livestock health and production based extension services in the state line departments, there is an urgent need to provide qualified veterinary extension specialists or alternatively give intensive training on Animal Husbandry and Veterinary extension programmes to the existing agriculture extension workers. (Action: SAUs/DUs/CAU)
4. ICAR should take the responsibility of training the faculty in SAUs and DUs on distance education and learning techniques and developing the course content with the involvement of agencies like IGNOU, ICRISAT, NAARM, Department of Information Technology etc. (Action: ICAR)
5. A provision may be made for engaging experts for awareness creation and training of the faculty in SAUs, DUs, CAU in distance education activities from the ICAR Education Development Grant under the Head HRD. (Action: ICAR)
6. A regional consortium approach for creating infrastructure for development and delivery of distance education to the clienteles should be supported by ICAR to strengthen the existing distance education facilities at SAUs, DUs and CAU. (Action: ICAR)

The Regional Meeting was held at Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Srinagar (J&K) on 9-10th September 2005

"Policy paper on Control of admission, improvement in examination/ evaluation system and invigilation of examinations, course curricula and mechanism for affiliation of private colleges with SAUs"

Recommended Policy Guidelines on Private Agricultural Education

(A) Affiliation:

1. The management of the private college/institution should be transparent and the affiliation of such private college, imparting UG/PG teaching in agriculture and allied sciences, need to be invariably under the regulatory control of SAUs alone.
2. All private Agricultural colleges should be affiliated with State Agricultural Universities of their respective region (SAUs/DUs/ICAR) and follow similar system of education and guidance. SAU Model Act does not allow affiliation, as a result many agricultural colleges are affiliated with traditional universities. Element of affiliation should be incorporated in the Model Act.
3. All existing private colleges of agriculture and allied sciences affiliated to traditional universities should now be affiliated with the SAU of the region.
4. Affiliation should be temporary, for a period of 10 years, subsequently renewable by adopting norms relevant at that time. Non-compliance of norms will make affiliation liable to cancellation by the Vice-Chancellor of SAU concerned.
5. To curb mushrooming of private colleges there should be substantial amount of affiliation fee as being charged by TNAU, for each course.
6. Affiliation procedure should be well laid out in consonance with the university academic processes and mandate.
7. Every SAU shall develop a perspective plan in term of agricultural academic institutions needed for its area of jurisdiction for intensive production agriculture, processing and value addition and quality rural life.

(B) Accreditation:

1. There is need for establishing accreditation norms for affiliated private colleges. SAUs may enforce the accreditation norms before affiliation through an Accreditation Committee constituted by the concerned SAUs. One of the Members may be ICAR nominee.
2. Costs involved in accreditation should be borne by the institution seeking affiliation.

3. Accreditation procedure should be well laid out.

4. Establishment of a private college or a new programme in already affiliated college should be opened with prior approval of the SAU concerned. College seeking accreditation/affiliation should have minimum 20 ha cultivable land of which 10 ha should be available for agricultural experimentation.

5. Accredited private colleges should be eligible for financial assistance from ICAR.

(C) Admission

1. The admission procedure to various courses of both constituent as well as affiliated private colleges need to be in accordance with the practice in vogue in the SAUs to which the college is affiliated.

2. Annual induction to a private college should include 50% of the seats to be admitted common entrance mechanism of the SAU and remaining 50% may be filled by college on merit basis.

3. 15% of the total seats in the private colleges may be filled by the Management body of the college.

4. There should be a merit quota of 15% seats having same fee structure as that of SAU.

5. The intake capacity should commensurate with the facilities available with the college but subject to a maximum of 64 in a UG programme.

(D) Academic Standards:

1. Affiliated college should recruit/employ qualified competent teachers for which the pay structure shall be similar as prevalent in SAU.

2. The minimum qualification for appointment of teachers in the affiliated private colleges should be Masters' degree with NET, giving preference to candidates with doctorate degree.

3. The college management committee should include Dean and concerned Director. Resident Instruction or nominee of the Vice-Chancellor as members.

4. The teachers at affiliated colleges should have opportunities for training, participation in seminar and symposia.

5. Before accreditation/affiliation it must be ensured that the institution has prescribed laboratories, library and other instructional infrastructure.

6. Preference should be given to active young teachers in recruitment of teachers. However, retired teachers may be hired on short term basis.

7. Affiliated colleges should have logical institutional framework with departments headed by professor/Associate Professor.

(E) Regulation on Resident Instruction:

1. Resident Instruction Rules and procedures/Academic regulations of the SAU concerned

2. Periodic monitoring of the academic programmes and its delivery should be undertaken by SAU concerned.

3. Where number of Affiliated colleges justify there may be a Controller of Examination at SAU for systematized examination and evaluation.

(F) Course Curriculum:

1. Course curriculum and academic regulations at affiliated colleges should be same as following by the SAUs for their constituent colleges.

2. To have uniformity in agricultural education, semester system of teaching should be mandatory.

3. Attendance of the students in affiliated colleges should be the same as prescribed in SAU.

4. Affiliated colleges should have the extracurricular activities for overall development of the students such as Commercial Agriculture, NSS, NCC, study tours etc.

5. The PG programme should invariably include thesis dissertation as being followed in SAUs.

(G) Examination/Evaluation and Invigilation:

1. The academic calendar of the Affiliated College academic calendar including registration and examination schedules should be the same as that of the SAU.

2. Examination, invigilation, evaluation and award of the transcript and degree/ certificate etc. should rest entirely with SAU.

3. For promoting active participation of the student in learning processes, evaluation should have internal marks, at least 40%.

4. The setup of the question papers should include objective, short note and descriptive type questions covering the entire syllabus with limited optional/ choice.

5. In order to curb unfair means there should be a Chief Invigilator(s) to supervise the conduct of examination, appointed by the SAU.

6. Answer books for evaluation should be coded, forwarded and confidentiality ascertained.

7. Supplementary examinations should be done away with.

(H) Other

1. Failure to comply provision of MOU/directives of the University within the stipulated time, the Vice-Chancellor may withdraw the affiliation.

2. Affiliated colleges should have student gymkhana and playgrounds. They should also be part of the SAU sports and other cultural activities.

3. Graduates of affiliated colleges should also be entitled for service placement of the SAU.

Recommendations of National Symposium held at Indira Gandhi Agricultural University, Raipur on 10-11 November 2005

"Agricultural technological backstopping through education and training for Self-employment"

1. HRD programmes should be liberal and timely implemented.
2. One percent of Agricultural GDP should be allocated to NARS with rational distribution to education, research and extension education.
3. There is need to examine the existent course which have many good aspects and change the curricula if needed.
4. It is necessary to strengthen the areas like taxonomy, disaster management, IPR etc.
5. There is a great need to revamp the Home Science course curricula.
6. The SAUs have a great strength to internationalize higher education and for this necessary specialization, infrastructure etc. need to be developed.
7. SAUs may identify the niche areas and develop the needed course curricula in the niche areas across the disciplines for attracting international students.
8. ICAR may provide proper guidelines for the course equivalence of graduate students from foreign countries.
9. It is necessary to develop course curricula and necessary infrastructure for offering vocational courses in Agriculture, Veterinary sciences, Animal husbandry, Dairy Sciences and Fisheries.
10. Trained technicians are needed and vocational courses in dairy sectors are to be developed and popularized among the youth especially rural youth.
11. Some scope may be given for consideration of need based courses also in addition to the common one taught in the light of uniformity.
12. Uniform admission procedure should be adopted in all SAUs.
13. There may be agricultural engineering extension specialization in SAUs.
14. Close collaboration with industrial extension centers and R&D institutes.
15. Extension workers to farmers ratio is very wide. There is a need to reduce the gap in order to make the extension effective. Agri-clinics and Agro-business centers can fill the gap and support the extension services.

16. Confidence building among the students is the need of the hour. There must be some curricula to built up confidence among the students to develop self-employment. For such activities the infrastructural developments funds support should come from ICAR.

17. Privatization of extension services is inevitable in the present context of agriculture. Even other countries in the world are doing privatization. It is necessary to have public-private sector linkage and coordination for agricultural extension.

18. E-extension has a great potential in India. Development of rural infrastructure is necessary for utilization of the e-extension potential in India.

19. Contract farming can, in one way, help the small and medium farmers to get assured technological support for crop production as well as assured marketing to their products. However proper legislative protecting measures are needed to avoid exploitation of the farmers.

20. In rainfed areas, blending of traditional and modern technologies is very much needed for better adoption of technology.

Major recommendations selected by IAUA General Body for forwarding to concerned authorities for implementation out of discussion held under session III during 30th IAUA Convention

Recommendations of 29th Convention held at CCS HAU, Hissar, on 12-13 January 2005 "Quality of Agricultural Education in the context of National and International Commitments"

1. ICAR should have a major role in regulatory planning, formulation of norms, accreditation and integrated development of education and avoidable proliferation of the institutes. ICAR should have statutory powers. (ICAR)
2. Education for entrepreneurship should be promoted. (SAUs)
3. SAUs should have Think Tank, Task Force and WTO cell/agribusiness Centre. (SAUs/ICAR)
4. Mobility within and between NARs/SAUs/DUs networking and ICAR/ SAUs participation of Ph.D. students in academic activities should be encouraged. (ICAR Institutes/SAUs)
5. India can be service provider in developing countries for helping HRD in Africa, Middle East etc. In that context, India should set up a consortium for logistic support. Exchange of students and faculty with foreign institutes should be institutionalized. (ICAR)
6. International research should be more strategic in its application, and we should move from commodity centre to system approach, disciplinary to inter-disciplinary research, combine traditional knowledge with modern science and bring in right balance between national and international agenda. (SAUs)

(b) Recommendations of Brain Storming Session held at IVRI, Bangalore Campus during 17th - 18th August 2005"Distance Education In Agriculture"

1. There is general consensus that SAUs, DUs and CAU should not award formal degrees through ODEL in agriculture and allied disciplines at present and instead focus on catering to societal needs on demand driven vocational, entrepreneurial education and continued educational programmes for farmers, extension workers, rural youth and capacity building of agricultural graduates and faculty using ODEL. (ICAR)
2. As a first step, in capacity building on ODEL activities and programmes at SAUs, each university may identify a Nodal Officer to eventually establish a coordinating cell on Distant Education. ICAR should be approached for funding under National Agricultural Innovation Project (NAIP) for establishment of Distance Education Cells at all SAUs and CAU. (ICAR)

3. Considering the Paucity of Specialised cadre of Animal Husbandry and Veterinary extension workers to promote livestock health and production based extension services in the State line departments, there is an urgent need to provide qualified veterinary extension specialists or alternatively give intensive training on Animal Husbandry and Veterinary extension programmes to the existing agriculture extension workers. (State Govt. Live Deptt., Commissioner Animal Husbandry, Govt. of India)

4. ICAR should take the responsibility of training the faculties in SAUs and DUs on distance education and learning techniques and developing the course content with the involvement of agencies like IGNOU, ICRISAT, NAARM, Dept. of Information Technology etc. (ICAR)

(c) The Regional Meeting was held at Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Srinagar (J&K)on 9-10th September 2005 "Policy paper on Control of admission, improvement in examination/ evaluation system and invigilation of examinations, course curricula and mechanism for affiliation of private colleges with SAUs"

1. ICAR should have statutory power to regulate the agricultural education in the country to maintain desired quality of education.

2. All the recommendation presented by Dr. A. Alam were discussed and experience shared with the GB members. Further, it was desired that the recommendations be synthesized with the supporting documents in a printed form for necessary guidance to SAUs.

(d) Recommendations of National Symposium held at Indira Gandhi Agricultural University, Raipur on 10-11 November 2005 "Agricultural technological backstopping through education and training for Self- employment"

1. Two per cent of Agricultural GDP should be allocated to NARS with rational distribution to education, research and extension education. (Chief Secretary State Government, Planning Commission, ICAR)

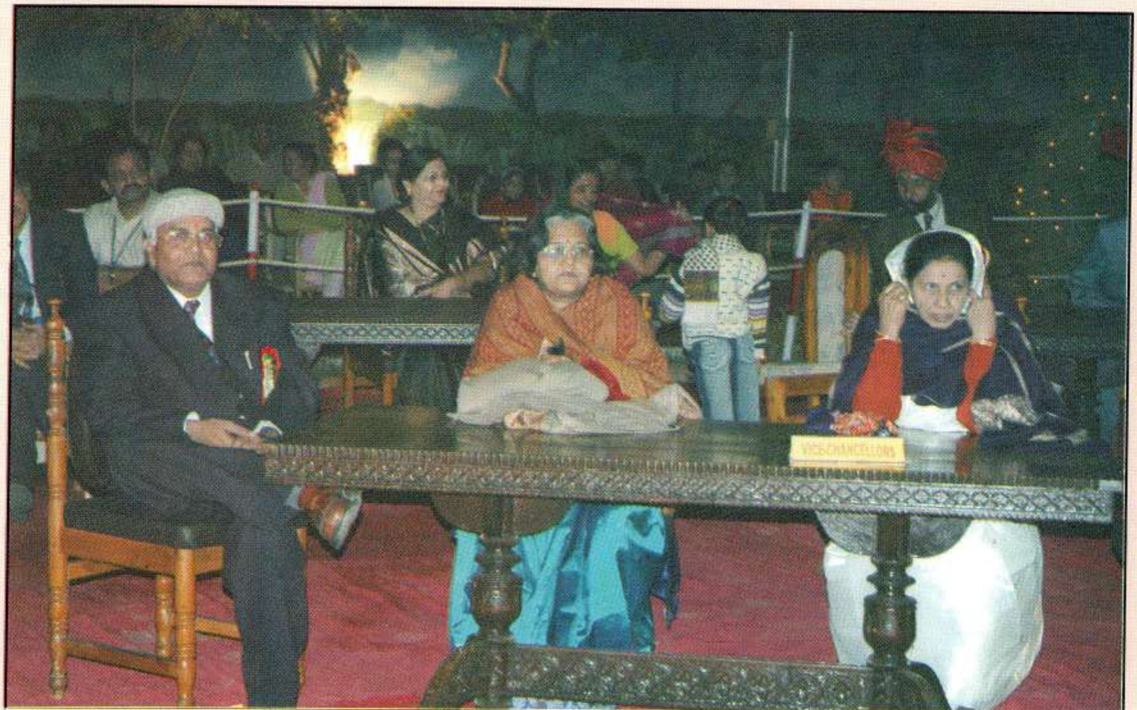
2. It is necessary to strengthen the areas like taxonomy, disaster management, IPR etc. (ICAR)

3. ICAR may provide proper guidelines for the course equivalence of graduate students from foreign countries. (ICAR)

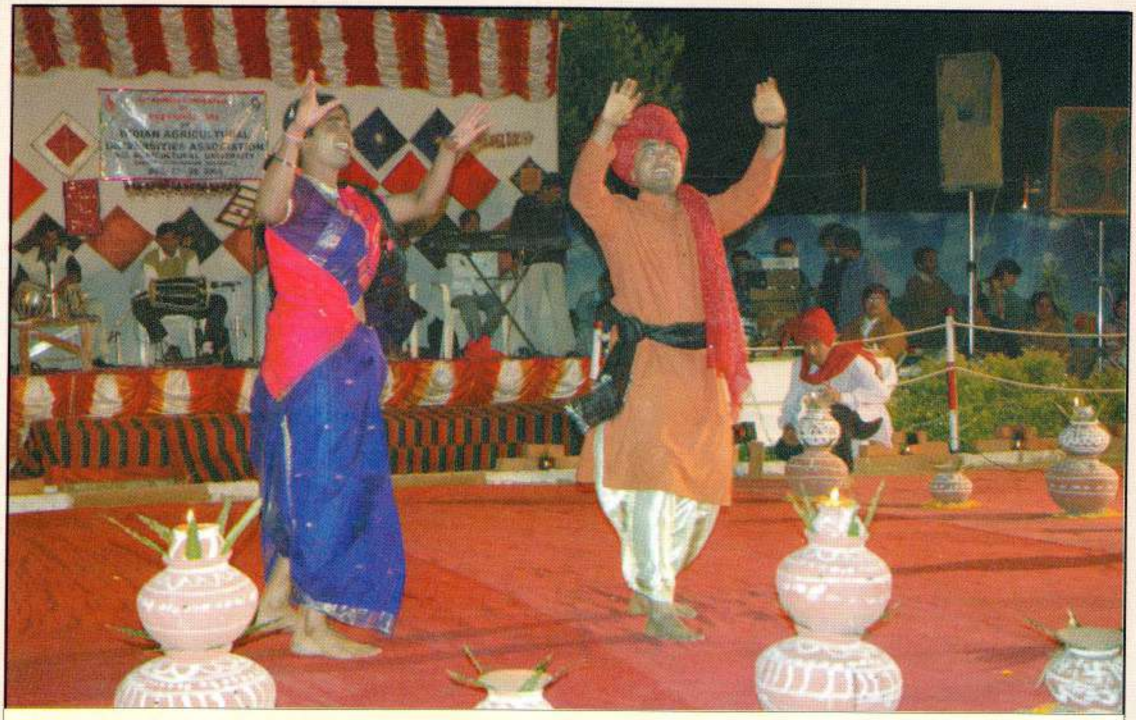
4. Uniform admission procedure should be adopted by all SAUs. (SAUs, ICAR)

5. Confidence building among the students is the need of the hour. There must be some curricula to built up confidence among the students to develop self-employment. For such activities the infrastructural developments funds support should come from ICAR. (ICAR)

6. Contract farming can, in one way, help the small and medium farmers to get assured technological support for crop production as well an assured marketing to their products. However proper legislative protecting measures are needed to avoid exploitation of the farmers. (Ministry of Agriculture, Govt. of India)



Dignitaries enjoying the cultural programme.



A pic. from cultural programme arranged in honour of the dignitaries.

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A pic. from cultural programme arranged in honour of the dignitaries.

A pic. from cultural programme arranged in honour of the dignitaries.

President, IAUA, Dr. S.N. Puri acknowledging the performance of the artists.

LIST OF PARTICIPANTS OF 30th ANNUAL CONVENTION OF IAUA

1. Dr. S.N. Puri, Vice-Chancellor, CAU, Imphal.
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5. Dr. K.V. Peter, Vice-Chancellor, KAU, Thrissur, Kerala.
6. Dr. B.S.Chundawat,Vice-Chancellor, SDAU, Sardarkrushinagar, Gujarat.
7. Dr. S.S.Baghel, Vice-Chancellor, AAU, Jorhat, Assam.
8. Dr. Parmatma Singh, Vice-Chancellor, RAU, Bikaner, Rajasthan.
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42. Dr. R.M.Kothari, Director, Jain Irrigation, Jalgaon, Maharastra.
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49. Dr. S.L.Goswami, Joint Director (Research), NDRI, Karnal, Haryana.
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51. Dr. N.K.Kalyansundaram, Professor (Agri.Chemestry), AAU, Anand, Gujarat.
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56. Dr. Rajesh Nigam, Registrar, Pt.DDUPCVV, Mathura, Uttarpradesh.
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58. Dr. R.M. Chauhan, Plannig Officer, SDAU, Sardarkrushinagar, Gujarat.
59. Dr. C. Senthil, Chief Scientist, Rajshree Sugar, Theni, Tamilnadu.
60. Dr. I. Johnkutty, Asoc.Dean, KAU, Pandanakkara, Kerala.
61. Dr. M.S.Sudhakar, Sr. Scientist, Jain Irrigation, Jalgaon, Maharastra.
62. Dr. S.S. Patel, Comptroller, SDAU, Sardarkrushinagar, Gujarat.

PROGRAMME OF 30th ANNUAL CONVENTION OF IAUA

Venue : Sardar Smruti Kendra, Conference Hall, SDAU, Sardarkrushinagar.

27th December 2005

Forenoon

Inaugural Session	Welcome Address :	*Dr. S.B.S. Tikka, Director of Research, SDAU, Sardarkrushinagar.*
	Keynote Address :	*Dr. K. C. Khandelwal, Advisor, Non Conventional Energy Resources, Ministry of NC Resources, New Delhi*
	Report on IAUA Activities :	*Dr. R. P. Singh, Secretary, IAUA, New Delhi.*
	Inaugural Address :	*Shri Bhupendrasinhji Chudasama, Minister for Agricultural & Co-Operation, Gujarat.*
	Presidential Address :	*Dr. S. N. Puri, Vice-Chancellor, CAU, Imphal & President, IAUA*
	Vote of Thanks :	*Dr. H. N. Kher, Registrar, SDAU, Sardarkrushinagar.*

Session-I : Crop residue recycling/management

Speaker :
- *Dr. S. S. Magar, Vice-Chnacellor, BSKV, Dapoli*
- *Dr. C. Senthil, Rajshree Sugar, Theni.*

Session-II : Energy generation from Agricultural Waste

Speaker
- *Dr. C. K. Teckchandani, Dean, JNKVV,Jabalpur*

Afternoon

Session-III : Discussion on Recommendations of

* 29th Annual Convention IAUA-HAU Hissar, January 12-13, 2005
* Brain Storming Session IAUA-Bangalore, August 17-18, 2005
* National Symposium IAUA-IGKV Raipur, November 10-11, 2005

Penelist : *Dr. S. A. Patil, Vice-Chancellor, UAS, Dharwad*
Dr. M. P. Yadav, Director, IVRI, Izatnagar
Dr. A. Alam, Vice-Chancellor, SKUAST, Srinagar
Dr. C. R. Hazra, Vice-Chancellor, IGKV, Raipur
Dr. S. S. Baghel, Vice-Chancellor, AAU, Jorhat

Session-IV : Discussion on Universities Problems

* Revenue Generation
* Modification of course curricula
* Student entrepreneurship
* Pro-active on other problems

Session-V : IAUA General Body Meeting

28th December 2005

Forenoon

Session-VI : Dairying and poultry farming waste management
Speaker

- *Dr. V. Thiagarajan, TNV&ASU, Chennai.*
- *Dr. M. J. Solanky, AAU, Anand*

Session-VII : Fruits and vegetables waste management
Speaker

- *Dr. K.V. Peter, Vice-Chancellor, KAU, Thrissur*
- *Dr. U. K. Kohli, Dr.YSPUH&F, Nauni*
- *Sh. R. M. Kothari, Jain Irrigation, Jalgaon.*

Afternoon

Session-VIII : Management of Agro-industrial waste
Speaker

- *Dr. N. K. Kalyansundram, AAU, Anand*
- *Dr. K. P. Patel, AAU, Anand*

Closing Ceremony

Various Committees Associated with the conduct of 30th Annual IAUA Convention

Organizing Committee :

Dr. B.S. Chundawat, Vice-Chancellor, SDAU, Sardarkrushinagar.

Dr. S. N. Puri, President, IAUA, Vice-Chancellor, CAU, Imphal.

Dr. S. S. Magar, Vice-President, Vice-Chancellor, Dr. B.S.K.K.V, Dapoli.

Dr. M. P. Yadav, Secretary-Treasurer, Director, I.V.R.I, Izatnagar.

Dr. S. A. Patil, Member, Vice-Chancellor, UAS, Dharwad.

Dr. K. S. Aulakh, Member, Vice-Chancellor, PAU, Ludhiana.

Dr. K. V. Peter, Member, Vice-Chancellor, KAU, Thrissur.

Dr. R. P. Singh, Executive Secretary, IAUA.

Reception & Registration Committee :

Dr. K. Shreedharan, Principal, Home Science College, SDAU, Sardarkrushinagar.

Dr. A.K. Jain, Professor, Veterinary College, SDAU, Sardarkrushinagar.

Sh. S.R. Vyas, Home Science College, Sardarkrushinagar.

Sh. V.R. Prajapati, Home Science College, Sardarkrushinagar.

Transportation Committee :

Shri U.H. Shah, Executive Engineer, SDAU, Sardarkrushinagar.

Shri. N.D. Joshi, Junior Clerk, SDAU, Sardarkrushinagar.

Stay Arrangements Committee :

Dr. R.M. Chauhan, Head of Department (Botany) & Planning Officer, SDAU, Sardarkrushinagar.

Sh. U.H. Shah, Executive Engineer, SDAU, Sardarkrushinagar.

Dr. T.K. Jambukia, Assoc. Professor, SDAU, Sardarkrushinagar.

Dr. C.J. Tank, Assistant Professor, SDAU, Sardarkrushinagar.

Sh. R.S. Prajapati, Senior Research Assistant, SDAU, Sardarkrushinagar.

Sh. G.S. Patel, Senior Research Assistant, SDAU, Sardarkrushinagar.

Sh. L.S. Chaudhary, Agril. Asstt., SDAU, Sardarkrushinagar.

Finance & Purchase Committee :

Shri S.S. Patel, Account Officer cum Comptroller, SDAU, Sardarkrushinagar.

Food and Refreshment Committee :

Dr. M.D. Arha, Research Scientist (Seed Technology), SDAU, Sardarkrushinagar.

Dr. S. Acharya, Research Scientist (Pulses), SDAU, Sardarkrushinagar.

Dr. J.B. Patel, Senior Research Assistant, SDAU, Sardarkrushinagar.

Sh. P.M. Thathia, Agril. Officer, SDAU, Sardarkrushinagar.

Sh. B.H. Patel, Agril. Asstt., SDAU, Sardarkrushinagar.

Sh. K.M. Momin, Agril. Asstt., SDAU, Sardarkrushinagar.

Programme Committee :

Dr. S.N. Jaimini, Research Scientist (Arid), SDAU, Sardarkrushinagar.

Dr. K.A. Thakkar, Professor, Extension Education, SDAU, Sardarkrushinagar.

Sh. J.M. Patel, Senior Research Assistant, SDAU, Sardarkrushinagar.

Sh. N.B. Patel, Senior Research Fellow, SDAU, Sardarkrushinagar.

Sh. Kartik Raval, Junior Research Fellow, SDAU, Sardarkrushinagar.

Exhibition and Interior Decoration Committee :

Dr. S.N. Jaimini, Research Scientist (Arid), SDAU, Sardarkrushinagar.

Dr. R.R. Shankhela, Associate Research Scientist (Arid), SDAU, Sardarkrushinagar.

Dr. K.D. Solanki, Associate Extension Educationalist, SDAU, Sardarkrushinagar.

Publication Committee :

Dr. K.A. Thakkar, Professor, Extension Education, SDAU, Sardarkrushinagar.

Public Relation & Media Committee :

Dr. M.R. Prajapati, Associate Extension Educationalist, SDAU, Sardarkrushinagar.

Cultural Programme Committee :

Dr. V.R. Patel, Associate Professor (Soil), Public Relation Officer, SDAU, Sardarkrushinagar.

Organizing Secretary :

Dr. S.B.S. Tikka, Director of Research & Dean P.G. Studies, SDAU, Sardarkrushinagar.

Front Photo : Sardar Smruti Kendra (Venue of the Convention)
Back Photo : Administrative Building of SDAU.

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