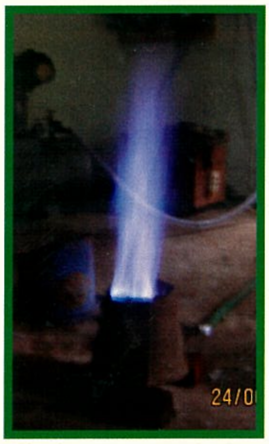
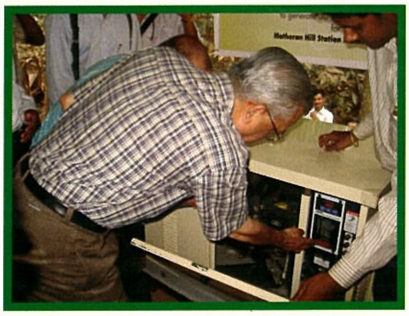
for MMR-Environment Improvement Society

NISARGRUNA BIO-GAS PLANT

MATHERAN HILL STATION MUNICIPAL COUNCIL

Final Project Report





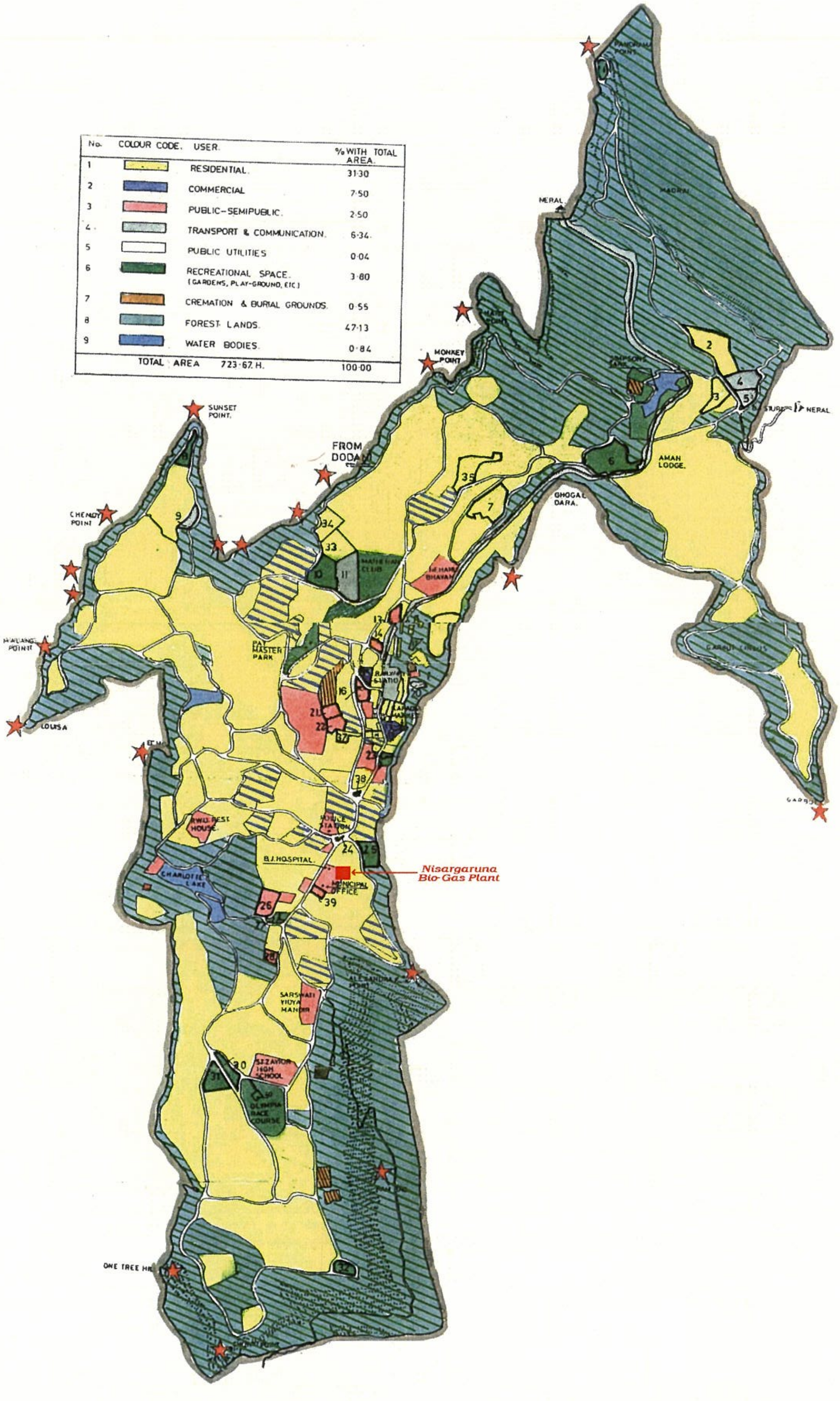
Project Financed By
Mumbai Metropolitan Region
Environmental Improvement Society

Executed By
Bhabha Atomic Research Centre

COMPLETE NISARGARUNA BIOGAS PROJECT

BIOGAS NISARGAJYOT

LOCATION OF NISARGARUNA BIOGAS PLANT



No.	COLOUR CODE.	USER.	% WITH TOTAL AREA.
1	🟨	RESIDENTIAL.	31·30
2	🟦	COMMERCIAL	7·50
3	🟥	PUBLIC-SEMIPUBLIC.	2·50
4.	▨	TRANSPORT & COMMUNICATION.	6·34.
5	☐	PUBLIC UTILITIES	0·04
6	🟩	RECREATIONAL SPACE. (GARDENS, PLAY-GROUND, ETC.)	3·80
7	🟧	CREMATION & BURIAL GROUNDS.	0·55
8	▨	FOREST LANDS.	47·13
9	🟦	WATER BODIES.	0·84
		TOTAL AREA 723·67. H.	100·00

Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy visit Nisargaruna Biogas plant at Matheran dated 23/3/2008.

1. Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy handover complete Nisargaruna Biogas project to Mr. Manoj Khedkar. President Matheran Municipal Council.

2. CONVERSION OF BIOGAS INTO ELECTRICITY GENERATOR KEY START BY DR.ANIL KAKODKAR.

VISITERS

1.DR.SHAM GOEL, PRINCIPAL SECRETARY, ENVIRONMENT DEPARTMENT GOVT.OF MAHARASTRA,SHRI.MANOJ KHEDKAR,PRESIDENT MMC ,DR.SHARAD KALE SR.SCIENTIST BARC VISITED NISARGARUNA PLANT

2.SOME FOREIGN VISITORS

3.SHRI.RAJAN KINE , CHAIRMEN STANDING COMMITTEE AND OTHER MEMBERS THANE MUNICIPAL CORPORATION VISIT TO NISARGARUNA PLANT MATHERAN

Project Report

Name of the project:

Installation and commissioning of NISARGRUNA BIOGAS PLANT of 5MT/day capacity for processing of biodegradable waste at Matheran Municipal Council Premises

Project partners:

1. Matheran Municipal Council, Matheran
2. Mumbai Metropolitan Region Environment Improvement Society, Mumbai
3. Bhabha Atomic Research Centre, Mumbai

Commissioning of the project: February 2007

Submission date December 15, 2008

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Executive Summary

Solid waste management has remained an unaddressed issue in most of the urban local bodies since independence and before. The easy option of throwing all the urban garbage on dumping yards has been adopted so far. Accelerated urbanization has resulted in increased garbage generation, scarcity of dumping yards and problems in transportation. The magnitude of garbage generated in city limits and its disposal has become such major issues that processing of garbage is forgotten. This is detrimental to the basic principle of conservation of matter, as dumping yards have become graveyards of essential resources. Municipal administration is desperate in solving these problems. The package involving segregation of garbage at source and decentralized waste management system appear to be slow but long lasting solution for this menace. Biodegradable waste processing is the key. Bhabha Atomic Research Centre has developed Nisargruna biogas technology for processing of the biodegradable waste that may offer a way towards a permanent solution.

Matheran Municipal Council, Mumbai Metropolitan Region Environment Improvement Society and Bhabha Atomic research Centre jointly took up a project for installation and commissioning of a BARC Nisargruna biogas plant for processing of biodegradable waste generated in the premises of Matheran Municipal Council. It took almost two years for completion of the project. The delay mainly was due to heavy monsoon and adverse working conditions prevailing at Matheran. The seeding of the digester of Nisargruna plant was undertaken in mid February 2007 and was completed by March 10, 2007. The waste processing started on March 11, 2007 and is continuing till today without any breakdowns or stoppages. The waste generated in Matheran is mainly kitchen waste from various hotels and horse dung. This waste is processed in Nisargruna biogas plant.

The experience of operating this technology in Matheran for last 20 months is encouraging. The process generates biogas and manure as by-products. There is no waste generation in this process. Waste is only consumed. **More than 1500 MT of waste has now been processed by this plant. The dumping yard of Matheran is now free of biodegradable waste.** The wastewater generated is recycled and utilised for garbage processing and gardening of the biogas project premises. Presently municipal staff is operating this plant. **The procedure for getting this plant certified for ISO 9000 is underway. This will immensely add to the value of the technology from environmental angle. It is encouraging to note that many urban local bodies in Maharashtra, Kerala and Karnataka are now in the process of installing such decentralized Nisargruna plants in their premises. Kalameshwar, Katol, Pandharpur, Kagal, Jaisingpur and Chiplun Council plants have become functional after Matheran and all of them are functioning satisfactorily. Several Municipal Councils like Bhandara, Wardha, Karanja, Beed, Ramtek, Pune, Khed, Alibag, Roha and Dapoli have initiated the work for constructing these plants.** This technology has a good potential to earn carbon credit and efforts are being done to get it. Matheran experience is reported here.

PROLOGUE

Since the formation of earth millions of years ago, elemental resources have remained the same. There is no increase or decrease in their quantities. They only change from one form to another. The natural cycles of elements are running in an undisturbed way since time immemorial. **Carbon dioxide is the key component of environment, which is responsible for providing vitality to the living world in the form of food. It is also responsible for green house effect.** A perfect balance is required to be maintained of this component in the environment. However the industrial revolution, population explosion and growing energy needs have spoiled this balance. We need to take sincere steps towards reducing the green house effects by reducing carbon emissions in the form of methane and carbon dioxide.

A glance at the biggest industries and the smallest technologies of today makes us aware of a strange falsity - a feeling of being detached from that which is real and true. This is the age of technology - the age where everything is done by man. But that has its negatives. We, as a planet, are in serious trouble. The only way out seems to be to go back to where we came from. We must go back to nature and seek solutions to our problems.

Waste handling and management are other major problems we are facing. This is mainly because of our attitude. The word waste has been so abused now that we all believe fully the concept. Waste is a resource and should be treated accordingly. We need to change mental attitude of our society. Although segregation is talked about a lot, practically there is no segregation in household waste. Hotels, restaurants and canteens also do not segregate their waste. This is mainly due to lack of civic sense. Segregation will not happen in one day. Every one of us will have to practice it rather than talk about it. Life style has changed markedly over last two decades. Easy money seems to be available in different sectors of the society. This has resulted in irresponsible attitude and behaviour. These changes have crawled in our society in an unassuming way but they have changed overall picture. The cars have increased and number of drunk drivers has also increased. Localities appear to be cleaner than before; dumping yards have become dirtier concomitantly.

The non-segregation practices result in mixing of biodegradable waste with useful dry waste rendering both of them useless. The biodegradable waste dumped in such fashion can spoil the environment by allowing harmful insects and bacteria to flourish under these conditions. We are unable to control epidemic diseases in our country mainly because of inadequate handling of solid waste. Still we have a large number of untimely deaths attributed to epidemics. The gases emitted at dumping grounds cause lots of respiratory problems to the people around this area. In winter when atmosphere is heavy, these gases tend to remain at surface levels and contaminate the breathing air at alarmingly higher concentrations. Many fire hazards are caused because of uncontrolled methane emissions at the dumping sites. Stray animals especially like dogs, pigs and rats become predominant in such unnatural ecosystems. They cause physical and physiological damages to surrounding ecosystems.

Usually dumping grounds are located outside the city limits. The distances could be anywhere between 3-4 KM to 25-30 KM from the farthest points. In such cases the transporting vehicles have to make several trips to deliver the waste at these sites. Since all these vehicles are running invariably using diesel as a fuel, pollution increases. This is highly energy intensive system involving a very large budget. It is estimated that costs involved could be anywhere between Rs. 1 to 3 per Kg of solid waste. Carbon emissions can certainly be controlled if we can reduce transportation needs at the source.

The leachates oozing out of dumping sites cause heavy contamination of ground water. This problem is more common in clay and silt soils. Rocky surfaces may help in reducing such contaminations; however that is very small consolation. Heavy metals and organic pollutants like polychlorinated benzenes, poly-aromatic hydrocarbons and pesticides are like to enter ground water through this route. It is difficult to decontaminate such water bodies because of the high volumes. What we achieve is creating more and more problems only. The sites needed for dumping are becoming more and more difficult to acquire due to increasing property values. Municipal bodies like Mumbai and other Metro cities in the country are over strained now to look for such sites.

We are facing considerable problems in satisfying energy needs of the society. The energy sources are depleting at a very fast rate. We need to look for different energy sources. The concept of renewable energy could not gather speed as would have been expected in light of oil crisis all over the world. Developing countries like India could not afford the initial vast investments required in renewable energy projects. What is the economics? This is a major question asked by all administrators and city planners for all such projects. We can't blame them. They have a job to be done and they are right. Energy may be everyone's problem, but the alternatives have to be viable and reliable. Waste may not be a likable item for anyone, but its handling is a real thorny issue for our city planners. Here the country needs a different approach. We will have to be non-conventional in our thinking, without being illogical, to make renewable sources as our conventional energy means. The famous scientist Dr. Carver had said, "Society finds it difficult to change the routine approach towards life. The change should come in such a way that people should not even know that they have changed." Biogas can provide us a substantial portion of our energy needs.

A major constraint in wide scale acceptance of biogas in the society is probably mental attitude rather than its energy value. Especially in our country, the term biogas is closely associated with gobar gas. Gobar gas units have actually played an important role in village economy in seventies and eighties. Even today one can find some excellently run gobar based biogas plants in several parts of the country. However it could not become our flagship renewable energy scheme mainly because of inadequate research and development of the process. Inputs from engineering aspects brought some better models like Deenbandhu, fixed dome, KVIC floating dome etc. However the scope remained very limited as only gobar could be processed in such plants in sustainable manner. The weaker biogas flame, reduced animal holdings and therefore unavailability of gobar and generally lack of maintenance, resulted in reduced number of active plants. Europe, on the other hand, saw phenomenal increase in biogas units mainly because of organized research and developmental efforts. In many European countries, vehicles are run on biogas. What an irony then that several companies in Europe are trying to sell their technology in India!

The fourth aspect after environment, health hazards and energy crunch that is causing a major concern is fertility of soil. The fertile Indian soils have fed millions and millions of people since time immemorial. Ours has been known as an agricultural country all over the world. India is also blessed with a good amount of forest cover. Yet all is not well in this prime discipline that faithfully continues to serve us. Another quote of Dr. Carver tells us that the future of the country is safe only if the topsoil layer is safe. A continuous exploitation of our soils over several thousands of years has caused depletion of organic carbon. Organic carbon is the soul of fertile soil. The chemical fertilizers can only supplement the soil; they cannot build the soil. Excess and untimely applications of such fertilizers have proved detrimental in many areas and the top soil layer has been irreversibly damaged. Excessive irrigation has also significantly contributed to this loss. Such soils will be sick and will not be able to provide any protection to the standing crops. In the era of highest population becoming higher every day, this is a cause of serious concern. The only solution is replacement of this soil layer by the organic matter. Organic matter can build our soils in a sustained fashion.

SOLID WASTE MANAGEMENT SCENARIO IN INDIA

Law of conservation of matter and law of conservation of energy run this world. Matter and energy can neither be created nor destroyed. They only change through various forms. The various elemental cycles keep running at a steady pace. The life on earth is part of this cycle. The Life Cycle is thus an integration of various elemental cycles. It is important that all these cycles must continue in an undisturbed fashion to maintain the Nature's Cycle. We must look at every material as a potential resource.

The concept of waste therefore needs to be revamped in totality. In fact there is no waste generated in Nature. Every component that is generated is a part of some cycle. Hence each waste should be reused. We must change the name of WASTE BIN to RESOURCE BIN. This will help to change the mental attitude.

In India, everything related to municipal solid waste is unscientific and chaotic. Uncontrolled dumping of wastes on dumping yards in towns and cities has created overflowing landfills. The reclamation of such areas has become impossible due to the manner in which dumping is done. There are also serious environmental implications in terms of ground water pollution. These dumping yards have become breeding grounds for many dreadful infectious agents who cause diseases like cholera, dysentery, jaundice, typhoid and diarrhoea. This adversely affects the general health of people of our country. The hospitals and primary health centers are always overcrowded. We have probably the largest proportion of infectious deaths in the world. Many young people have succumbed to jaundice and typhoid, cholera and tuberculosis in this country.

They otherwise could have transformed the world for us. Because of the mismanagement in waste handling, we have disturbed the national health and unfortunately continue to do so. The country appears filthy and dirty. Burning of waste causing an increase in particulate and obnoxious emissions causes air pollution. This is another health hazard. Many young people in urban area are asthmatic and 9 out of 10 times this is due to environmental pollution. It is high time that we take these things seriously and make sincere attempts to change the attitude of people at grass root level.

The key issues involved in solid waste management are

- **Growth in population and increasing garbage generation**
- **Segregation of waste at source in as many categories as practical**
- **Waste collection system**
- **Scientific processing of the waste materials depending on their nature**
- **Decentralized means to process waste to avoid multiple transfers and facilitate disposal**
- **Developing infrastructure for solid waste disposal and processing**
- **Developing information collection and processing system for solid waste management**

We are living in a false economy where the price of goods and services does not include the cost of waste and pollution. More than one-fourth of the municipal solid waste in India is not collected at all; 70% of Indian cities lack adequate capacity to transport the waste; and sanitary landfills to dispose off the waste are neither well-equipped nor managed efficiently. Many urban local bodies and Grampanchayats spend 10-25% of the budget for the solid waste management programme. In certain bigger cities the budget share of this sector can be even more. However even with large amounts of funds allocated to handle the city solid waste, these services are rarely provided to all the residents in a given locality. Solid waste generated is frequently left uncollected on the streets, in open areas and drains. At certain places the manpower is not enough and needs to be increased. In certain cities human resource available for solid waste management is underused or inefficiently used owing to lack of, or inadequate, planning and operational management. There is lethargy in this sector in general. It is often said that the roads in Mumbai used to get washed every day! We seem to be confused about handling the huge amounts of solid waste. This is because the main focus has changed slowly but surely and unfortunately in the wrong direction. The entire municipal administration is now busy in removing the bulk of the solid waste from their city limits. Invariably it has to be somebody's backyard. Huge funds are allocated to lift the solid waste from various parts of the city and then dump in a remote area causing problems of transportation and pollution to the environment. It is as if the concept of processing the waste has vanished. The major concern is how to find a huge piece of land for dumping the waste in crowded cities and metropolis. No body wants this waste to be in their backyard.

We must remember that the solution to the present totally mismanaged solid waste disposal is decentralized management of solid waste. Every household generates about 500g-1Kg wastes every day. The question is "If I can not handle this small amount of waste at my level, how can I expect municipal agencies to handle the huge amount of waste generated in the city?"

There is no policy document in our country, which examines waste as part of a cycle of production-consumption-recovery. There are no serious efforts to perceive in totality the issue of waste through a prism of overall sustainability. The efforts have remained fractured and no concrete measures have emerged even though there are several judicial interventions. The new Municipal Solid Waste Management Rules 2000, which came into effect from January 2004, fail, even to manage waste in a cyclic process. Waste management still is a linear system of collection and disposal, creating health hazards and environmental pollution. The municipal Corporations and Councils in the country are concerned only with acquiring more and more dump yards.

Our country is likely to face a catastrophe due to massive waste disposal problem in the coming years unless consolidated efforts are made jointly by all societal partners. The problem of waste has remained as one of cleaning and disposing as rubbish. But a closer look at the current and future scenario reveals that waste needs to be treated in totality, recognizing its natural resource roots as well as health impacts. Waste can be wealth; which has tremendous potential not only for generating livelihoods for the urban poor but can also enrich the earth through composting and recycling rather than spreading pollution as has been the case.

The segregation of waste has to be done properly. Mere separation as dry and wet is not going to be of much help in long term waste management programme. Although the removal of wet component does help the management to some extent, there is still inadequacy in the utility of both the components. We need to separate the waste in at least five different categories.

This type of segregation will not only reduce the waste-handling problem, it will definitely add value to different types of wastes in different colored bins. The collection of glass, plastic and metal scrap in purer form will help urban local bodies in earning revenue rather than spending money on their transportation. The green biodegradable material can be processed in decentralized NISARGRUNA biogas plants that are described herein. The contents of the fifth bin can go for landfill. The separation of biodegradable waste actually increases the recycle value of other type of wastes. Hence such an elaborate segregation may initially appear difficult, but ultimately this design only will get stabilized in the country. It is expected that urban local bodies will only have to carry the waste collected in grey bin. The overall transportation cost thus can be reduced substantially in their budget. The rag picker's organizations can be employed to handle the wastes in other bins. This can become a mass movement and set a path in resource handling. Stree Mukti Sanghatana, Mumbai has shown a way in some parts of Mumbai and Maharashtra. This lead can be picked up and given a boost. The housing societies may be requested to make arrangements for five such large bins in their compounds where residents can put the segregated waste. The municipal authorities then can make arrangements to lift this waste separately. The glass and metal scrap can be collected once or twice in a week. The green waste can be collected daily. The other two bins can be cleared at fixed intervals and the schedule will depend on how fast these bins are getting filled. This type of waste collection will certainly reduce the transport bill that the urban local bodies have to pay. The rationalization in waste collection followed by processing using appropriate and environmentally friendly and safe technology can be more economical both monetarily and for a beautiful future.

Increasing urban migration and a high density of population will make waste management a difficult issue to handle in the near future, unless a new and efficient approach is designed. There is massive migration going on from rural to urban sectors in many developing countries including India. Many European countries could restrict the overgrowth of their cities through urbanization of the village sector. However in our country the rural population is shrinking. This is mainly because our infrastructure to give the villagers basic amenities of life never could get the momentum, which was expected after independence. Our villages remained neglected while towns turned into cities,

cities into mega cities and mega cities developed tremendous strains on the local urban bodies to provide basic utilities. New consumption patterns and social linkages are emerging. India will have more than 40 per cent, i.e. over 400 million people clustered in cities over the next thirty years (UN, 1995) and this now appears to be an underestimation. Modern urban living brings on the problem of waste, which increases in quantity, and changes in composition with each passing day. There is, however, an inadequate understanding of the problem, both of infrastructure requirements as well as its social dimensions. Urban planners, municipal agencies, environmental regulators, labour groups, citizens' groups and non-governmental organizations need to develop a variety of responses which are rooted in local dynamics, rather than borrow non-contextual solutions from elsewhere.

Proper planning and operational management require the collection, analysis and interpretation of information on the physical environment and socioeconomic aspects of communities served, characteristics of solid waste generated, and physical and human resources available for solid waste management. It is, therefore, vital to establish a good information management system to support decisions made in planning and operational management of solid waste collection and disposal in each municipality. However, in developing countries, the importance of information and its management has not received adequate attention from most municipal authorities responsible for solid waste management.

In many instances, solid waste management is considered to be merely an activity to be carried out by the urban local body in which collection vehicles and equipment are purchased and workers are employed to collect solid wastes from generation points and transport them to dump sites. Vehicles and equipment are purchased and manpower is recruited as and when funds are available. The performance of the solid waste management services is evaluated only by visual observations of streets and disposal sites. The lack of equipment and human resources, rather than better utilization of these resources, is often considered to be responsible for the unsightliness and obnoxious odour of uncollected solid waste in streets and disposal sites. The shortage of funds is almost always regarded as the most serious problem.

However, this type of piecemeal approach does not lead to efficient utilization of available resources. Solid waste management under such circumstances is usually not sufficient. In order to develop more efficient solid waste management systems, the efficacy of systems, which are currently in operation must be assessed and improved systems be devised through planning and operational management processes. These planning and operational management activities require information to be collected and processed. In order to facilitate systematic collection, processing, storage and dissemination/utilization of information for planning and operational management, an information management system needs to be established. Such an information system for solid waste management gets its data from actual solid waste collection and disposal services and various other sources such as socioeconomic and land use statistics. The information collected is categorized and stored in a manner that will lead to its prompt retrieval for use in planning and operational management. In the planning process, information is used to establish solid waste management goals and targets for the planning period, evaluate the future resource requirements and make decisions on resource investment for solid waste collection and disposal services. The information on population, commercial and industrial development, quantity of solid waste generated, land use, etc. is used to predict the future levels of demand for solid waste collection and disposal services and to set target levels of solid waste management. Various alternative scenarios are then developed to meet the targets. An alternative scenario is chosen based on certain criteria such as cost effectiveness, and resource requirements are then determined and an investment schedule is made. In operational management, information is used to assess the efficacy of solid waste collection and disposal services and improve the performance of the solid waste management systems. Information will be required on operation and maintenance of vehicles and equipment, productivity of workers, performance of collection and disposal services, and expenditures. The information generated from actual operation of solid waste management services is collected regularly on daily basis and stored in a computer. Socioeconomic information relevant to solid waste management is also collected and stored. This data is then processed to provide information in a useful form for subsequent use.

In addition to the aforementioned operational data on solid waste management and socioeconomic statistics, information from technical publications, legal documents and environmental data such as those required for environmental impact assessment of solid waste processing and disposal facilities are also used in planning, designing and operating solid waste management systems. This type of information does not easily fit into the information management scheme mentioned above, but it can be managed by a system similar to that used for library operation. Therefore, the system for the management of literature information should be developed separately, and as it is relatively well-known to most readers, this type of information management system will not be described further in this publication. In the following sections, a framework to evaluate solid waste management services is presented, which will provide a basis for selecting indicators useful for analysis and decision-making in planning and operational management.

A major problem in management of solid waste is segregation at source. After the industrial revolution, the waste production has become prominent due to human civilization activities. The rapid increase in the density of population in some of the urban cities has made the waste unmanageable due to problems associated with its collection, transportation and disposal. The ill-managed waste leads to unavoidable depletion of natural resources and health hazards. In the absence of waste segregation practices, recycling has remained to be an informal sector working on outdated technology, still thriving owing to waste material availability and market demand of cheaper recycled products. Paper and plastic recycling have been especially growing due to continuously increasing consumption levels of both the commodities. The presence of degradable solid waste in total waste makes the whole business of waste recycling hopelessly futile.

We need to separate our waste into as many categories as possible to make economically viable recycling possible at every level. The European countries have shown us the way in this regard. The waste is collected in different colored bins in many of these countries. Let us follow a plan given in figure 3. If we can segregate our waste at source in this way, the municipalities are sure to welcome this plan. Thereby the recycling potential will improve and burden and cost of transportation will substantially be reduced. **The micro planning can solve the macro problem**.

It may be hard to accept, but true to fact, that the government's policy to promote small-scale sector in India has fatal fallout—highly toxic metal dumping in densely inhabited North Delhi region. It has been conclusively found out that small industries have been regularly dumping extremely hazardous waste in and around Delhi, actually anywhere possible in total disregard to human life. Hazardous wastes like metal finishing wastes including lead, cadmium, chromium, zinc, ETP (effluent treatment plant) sludge, and acid and alkaline wastes have been found disposed in the busy Wazirpur area (Fundamental problem of waste generation and disposal in Delhi, TERIVISION, 2001). The degradation of Mithi river has been recently been brought out by 26th July, 2005 floods in Mumbai.

Waste from residential and commercial sector, food-processing industries, slaughterhouses and agricultural activities have high organic fraction making them suitable for the aerobic-anaerobic digestion. Most of the mechanically sorted fraction of municipal solid waste is sent to the dumping site although significant methane yield (0.07-0.43 m^3/kg VS added) at different retention times, ranging from 6-42 days, has been reported. Food waste like cooked meat, cabbage, boiled rice and mixed food waste, kitchen waste, fruit and vegetable market waste have also been found as good substrate for aerobic-anaerobic digestion during laboratory studies. Extensive research has already been done on energy efficient digestion of organic solid waste [particularly biomass]. But the need is of development of a system which is not scale sensitive and hence can be used in decentralized manner, there by reducing the cost of transportation and avoiding accumulation of waste at the site of generation. Moreover, it should have a capability to handle the waste in more convenient, efficient, economically and socially acceptable manner

NATURE AND MAGNITUDE OF GENERATION OF WASTE

Management of municipal solid waste is one of the basic obligatory duties of the urban local bodies in our country. The plague incidence in Surat was responsible for framing the Municipal Solid Waste (Management and Handling)

Rules 2000, under the Environmental Protection Act 1986. Waste generation broadly includes activities in which materials are identified as no longer being useful in their present form. They are either thrown away or gathered together for disposal. The rough estimate of total municipal waste generated in urban India is about 100,000 TPD (metric Tones per day). There is a steep increase in this figure in last few years. The quantum of rural and mainly agricultural waste is not included in this estimate. The cattle dung, forest biomass and agricultural waste together can fulfill a large section of our energy and manure needs. However in absence of a firm policy for handling these resources, the national economy is suffering a major setback year after year. The environment is also affected by this negligence.

There are qualitative and quantitative differences in waste generated in different urban populations. Table-1 brings out these differences. It is interesting to note that the quantity of waste generated goes on increasing with increasing population in a locality. The rural picture is quite different as there is a tendency to use the waste for animal feeding or composting in the fields and use that as supplement for earning.

Table 1: Waste generation per capita in urban area as a function of population

Population range (in lakhs)	**Average per capita waste generation (g/capita/day)**
1-5	210
5-10	250
10-20	270
20-50	350
50+	500

In our cities the waste is generally not weighed but measured by volume to quantity of waste generated is normally in the range of 0.2 to 0.5 Kg/capita/day. In metropolitan cites, this may be little higher. Mumbai generates about 7000 TPD waste and has a population of about 11-12 million. The changing urban scenario in India is shown in the Table-2.

Table-2: Changing Urban Scenario in India

Parameter	**1991**	**2004**
Total population (crore)	84.6	108
Total urban population (crore)	21.7	35
Total number of municipal bodies	>3700	>3700
Number of metro cities	23	48

The information infrastructure in the developed world helps in generating useful data for planning, management and handling of municipal solid waste in an efficient and scientific manner. We can follow a similar path, as all such facilities are now easily affordable in our system. The Nisargruna biogas plant at Matheran provides an ideal example to reduce and process the biodegradable waste. It would also add value to other non-biodegradable wastes if we can implement the concept of segregation at the source. We need many such plants at various levels. A roadmap to achieve the objective of "ZERO WASTE" must be carefully drawn and followed in a realistic time frame.

WASTE FEEDING SYSTEM

1.GARBAGE PROCESS IN MIXER

2.FINAL WASTE SEGREGATION

3.WASTE TRANSPORT SYSTEM

METHODOLOGIES IN HANDLING SOLID WASTE

The conventional technologies used to handle municipal solid waste in India are:

1. **Dumping**
2. **Composting**
3. **Land-filling**
4. **Incineration**
5. **Vermiculture**
6. **RDF**
7. **Anaerobic digestion**
8. **Nisargruna biogas technology**

Urban local bodies and Gram Panchayat are responsible for collecting and disposing the city and village solid waste.

1) **Dumping** is followed almost throughout the country despite the Supreme Court intervention in the matter. Many Urban Local Bodies maintain that they do not dump their waste. However that is not true in most of the cases. Mumbai has four large dumping yards where most of the city waste is dumped. A very small percentage of waste is either recycled or treated.

The major disadvantages of dumping are:

- Wastage of valuable resources: Solid waste generated in various houses, establishments, localities, hospitals, academic institutions, private and public sectors and government premises contains a substantial portion of reusable materials. Reuse and recycle are basic laws of nature. These useful resources are rendered totally useless due to lack of segregation at source. Although in mega cities rag pickers and slum dwellers collect some of the useful refuge, fairly large quantities get permanently locked at the dumping grounds.
- Transportation costs: Usually dumping grounds are located outside the city limits. The distances could be anywhere between 3-4 KM to 25-30 KM from the farthest points. In such cases the transporting vehicles have to make several trips to deliver the waste at these sites. Since all these

vehicles are running invariably using diesel as a fuel, pollution increases. This is highly energy intensive system involving a very large budget. It is estimated that costs involved could be anywhere between Rs. 1 to 3 per Kg of solid waste. Carbon emissions can certainly be controlled if we can reduce transportation needs at the source.

- Health hazards: The non-segregation practices result in mixing of biodegradable waste with useful dry waste rendering both of them useless. The biodegradable waste dumped in such fashion can spoil the environment by allowing harmful insects and bacteria to flourish under these conditions. We are unable to control epidemic diseases in our country mainly because of inadequate handling of solid waste. Still we have a large number of untimely deaths attributed to epidemics. The gases emitted at dumping grounds cause lots of respiratory problems to the people around this area. In winter when atmosphere is heavy, these gases tend to remain at surface levels and contaminate the breathing air at alarmingly higher concentrations. Many fire hazards are caused because of uncontrolled methane emissions at the dumping sites. Stray animals especially like dogs, pigs and rats become predominant in such unnatural ecosystems. They cause physical and physiological damages to surrounding ecosystems.
- Ground water contamination: The leaching liquid oozing out of such sites cause heavy contamination of ground water. This problem is more common in clay and silt soils. Rocky surfaces may help in reducing such contaminations; however that is very small consolation. Heavy metals and organic pollutants like polychlorinated benzenes, poly-aromatic hydrocarbons and pesticides are like to enter ground water through this route. It is difficult to decontaminate such water bodies because of the high volumes. What we achieve is creating more and more problems only.
- Space constraints: The sites needed for dumping are becoming more and more difficult to acquire due to increasing property values. Municipal bodies like Mumbai and other Metro cities in the country are over strained now to look for such sites. The dumping sites welcome us at the entrance of our city. This is not a healthy sign.
- Public outcry: Nobody will like to have somebody’s waste in their backyards. Same is true with Urban Local Bodies and Gram Panchayats.

Why a Gram Panchayat should permit dumping of city waste in their premises? The people staying around dumping yards experience "HELL" every moment. In a radius of few kilometers, population has to compulsorily smell those obnoxious gases coming out of the dumping yards.

Thus dumping yards only spell more and more problems in the attempt of city planners to get rid of the solid waste generated in their jurisdiction. They have generated huge public outcries, wastage of valuable resources and health hazards. Other than they have achieved nothing.

9. **Composting**: Composting is the biological process by which microorganisms convert organic materials into a humus-like material called compost. It has been commonly used for centuries to dispose of organic residuals. Modern composting differs from that occurring naturally only in the intentional creation of conditions through the application of scientific knowledge and technology to promote rapid decomposition of organic material and to better control the quality of the final product in an environmentally sensitive manner.

Benefits of Composting: Composting offer attractive benefits to the agriculture, and environment.

Benefits of the compost to the environment:

- Conserves the water and soil
- Protects groundwater quality
- Avoids methane production and leaching in landfills
- Drastically reduces the need for pesticides and fertilizers
- Buffers soil pH levels

Benefits to agriculture:

- Suppresses certain plant diseases and parasites and kills weed seeds.
- Reduces fertilizer requirements.
- Reduces water requirements and irrigation.

- Increases profits because of the higher prices paid for organically grown crops.

Other benefits

Revenue can be generated for composting operations through the sale of the finished product. Maintaining optimum microbial activity in the compost pile is essential for the decomposition of organic materials. Any factor that slows microbial growth also impedes the rate of the composting process. Factors necessary for optimal microbial activity include proper aeration, sufficient moisture, particle size, and nutrient balance, particularly nitrogen. The ideal levels of the biological, chemical, and physical needs that should be maintained throughout all stages of composting for peak performance are-

- Biological processes. Microorganisms are the key to the composting process. The ideal conditions for a given microbial population must be present for the composting process to progress at the proper rate. Under ideal conditions composting occurs rapidly. The focus of the management of the compost process should be the microorganisms and promoting conditions that lead to rapid stabilization of the organic materials.
- Physical processes. The essential physical requirements in the compost process are temperature, particle size, mixing, and pile size.
- Chemical processes. Many factors influence the chemical environment for composting. Some of the most important ones include: (a) the presence of an adequate carbon (food)/energy source, (b) a balanced amount of nutrients, (c) the correct amount of water, (d) adequate oxygen, (e) appropriate pH, and (f) the absence of toxic constituents that could inhibit microbial activity.
- **Disadvantages of composting: Scientific composting has relatively lesser disadvantages.**
- However, one is never sure whether composting is done scientifically especially while handling municipal solid waste. Urban local bodies in Maharashtra opt for composting because they do not have to worry about the process and composting does not need any special attention! However there are very few success stories of composting as effective disposal method.

- Composting of mixed municipal solid waste can be a very dangerous method as it is likely to give hazardous manure. It would contain heavy metals, plastics and hazardous organic chemicals like polycyclic aromatic hydrocarbons, dioxins and polychlorinated benzenes. These pollutants can be detrimental to fertility of soil and continuous application of such manure will have long lasting effects on food chain prevalent in that ecosystem.
- When we look for an option for treating large quantities of municipal solid waste, composting may have space and health related and aesthetic problems. Huge segregating machines are available to separate the waste, however, their maintenance can be very expensive and labour intensive.
- Composting does release a large quantity of biogas. Being in an open environment, it is impossible to trap the biogas and hence it gets mixed in the surroundings causing green house effects.

Sanitary Landfills

Landfills are the primary way to dispose of solid waste. Landfills are a necessary component of any municipal solid waste management system. Waste recycling efforts, recycling, incineration, and composting can reduce the quantity of materials sent to a landfill, but there will always be residual materials that require land filling.

Disadvantages of Land filling of Solid Waste: Several concerns associated

with using landfills for waste disposal are identified.

- The uncontrolled release of landfill gases that might migrate off-site and cause odor and other potentially dangerous conditions.
- The impact of the uncontrolled discharge of landfill gases on the greenhouse effect in the atmosphere.
- The uncontrolled release of leaching liquid that might migrate down to underlying groundwater or to surface water.
- The breeding and harboring of disease vectors in improperly managed landfills.

- The health and environmental impacts associated with the release of the trace gases arising from the hazardous materials that were often placed in landfills in the past
- The availability of landfill sites is always a limitation.

10.**Incineration:** Incineration is the controlled burning of waste at high temperatures in a facility designed for efficient and complete combustion. The technologies like briquette, RDF Incineration are all disguised incineration methods. Incineration generates carbon dioxide, water, sulfur dioxide, ash, gases, and heat energy. Not all waste can be processed in incinerators; only about 50% of municipal solid waste is combustible. Municipal waste incinerators are designed to accommodate waste with widely varying compositions; industrial waste incinerators are designed to burn a more homogeneous fuel. Energy recovery is a feature of most modern incinerators. In large cities like Mumbai, Delhi, Kolkata etc., the scarcity of land for land filling and lack of other methods of solid waste disposal, incineration is the most common method of handling waste. Specific benefits identified for the incineration of solid waste are: reduction of volume and weight of waste [Incineration reduces the volume of the combustible portion by approximately 90% and the weight by about 70%], destruction of certain chemicals or alteration of chemical characteristics including most hazardous chemicals, destruction of pathogens.

Disadvantages of incineration

Air pollution and disposal of ash are the two major concerns of using incineration to process municipal solid waste. Air pollution results when heavy metals and other airborne chemicals vaporize and are emitted from smoke stacks of incinerators. The cost of running an incinerator is very high and infrastructure and maintenance need continuous monetary inputs. The more developed nations are doing away with incinerators because of their astronomical cost; developing countries have become potential markets for dumping such technologies. Incinerators emit dioxins, furans and polychlorinated bi phenyls that are carcinogenic and deadly toxins. They lead to damages to the endocrine systems, among other health hazards. Conventional toxins like mercury and many other heavy metals are also released during incineration. Pollution control costs make such incinerators very expensive especially for our precariously placed economy. The better air controls obtained by spending such high costs still do not serve the purpose as the pollutants are transferred to land and water bodies through scrubbers and filters. There is also the problem of disposal of ash contents in the incinerator. These measures go against the MSW Management Rules 2000 where source segregation is expected to be done for cleaner processing and recycling.

The most important disadvantage of incineration is that there is a short circuit in biogeochemical cycles. The materials have to be processed in their natural cycles that have to be through microorganisms. Mineralization and immobilization are the two key processes linking the living world with non-living components. They have to be complementary and cyclic. Burning of organic form of waste does lead to mineralization without involvement of microorganisms. This would cause disturbance in the precariously operated natural elemental cycles and the results could be very damaging for the very existence of the living world. Hence incineration should be stopped at every level.

11. **Vermicomposting:** Vermicomposting uses earthworms to turn organic wastes into very high quality compost. This is probably the best way of composting small quantities of kitchen wastes. Adding small amounts of wet kitchen scraps to a large compost pile in the garden day by day can disrupt the decomposition process so that the compost is never really done. But it works just fine with Vermicomposting. Vermicomposting consists mostly of worm casts (poop) plus some decayed organic matter. In ideal conditions worms can eat at least their own weight of organic matter in a day. In fact it seems they don’t actually eat it – they consume it, sure enough, but what they derive their nourishment from is all the microorganisms that are really eating it. And yet their casts contain eight times as many microorganisms as their feed! And these are the microorganisms that best favour healthy plant growth. The casts don’t contain any disease pathogens – pathogenic bacteria are reliably killed in

the worms' gut. This is one of the great benefits of vermicomposting for crop growth.

Worm casts also contain five times more nitrogen, seven times more phosphorus, and 11 times more potassium than ordinary soil, the main minerals needed for plant growth, but the large numbers of beneficial soil micro-organisms in worm casts have at least as much to do with it. The casts are also rich in humic acids, which condition the soil, have a perfect pH balance, and contain plant growth factors similar to those found in seaweed. The only disadvantage of vermicomposting is its suitability for handling only small to moderate quantities of the waste. Worms are difficult to maintain. They are very sensitive to chemicals present in refuse.

Nature has used worms for keeping the fertility of soil. They have been given enzyme systems to do this job effectively. However use of these worms for degradation of biodegradable waste in very large quantities is deviation from natural processes. Such deviations would have long-standing effects on the ecosystem and will be known only after years. Worms liberate large quantities of nitrous oxide that is a dangerous green house gas. This effect would be accentuated in their artificial cultivation for waste disposal. Hence scientific conscience certainly gives a red signal for large-scale vermicomposting. It is also generally observed that the fluctuations in weather conditions could be detrimental for the survival of vermicultures. In last two decades we have witnessed weather changes that could be termed drastic. This is another factor that especially for urban local bodies could be difficult to handle.

12. **Refuse Derived Fuel (RDF) Technology:** Refuse-derived fuel or RDF plants take bulk waste and remove recyclable or non-combustible materials, the remainder then being dried and shredded or processed into a uniform fuel. This fuel has a calorific value much higher than that for municipal waste. Noncombustible materials such as glass and metals are removed during the post treatment processing cycle with an air knife or other mechanical separation processing. The residual material can be sold in its processed form (depending on the process treatment) or may be

compressed into pellets, bricks, or logs and used for other purposes either stand alone or in a recursive recycling process. Advanced processing RDF methods (pressurized steam treatment in an autoclave) can remove or significantly reduce harmful pollutants and heavy metals for use as a material for a variety of manufacturing and related uses. RDF is extracted from MSW using mechanical heat treatment, mechanical biological treatment or waste autoclaves. The production of RDF may involve some but not all of the following steps:

- Preliminary liberation (not required for autoclave treatment)
- Size screening (post treatment step for autoclave treatment)
- Magnetic separation (post treatment for autoclave treatment)
- Coarse shredding (not required for autoclave treatment)
- Refining separation

Disadvantages of RDF

It requires considerable space.

- A major drawback to combustion of waste is that the fuel is likely to be non-homogenous, damp and it will come in large fragments. The water content will lower the recoverable energy content per unit mass of fuel.
- The cost of the process is a major drawback. It is a capitally intensive process which has to be done on a grand scale if it is ever to pay off its costs.
- It is causing short-circuiting in elemental cycles that would be detrimental to Nature in long run.
- It is highly energy intensive and hence should not be permitted, as it would further stress our energy houses.
- It also contributes to global warming significantly.

7. **Anaerobic digestion (bio-methanation):** The process of biodegradation using anaerobic bacteria has been known to mankind for ages. Anaerobic digestion can help us to replace fossil fuels, reduce methane emissions from landfill sites and increase the efficiency of our energy system. It would certainly help us to fight climate change and it can solve many of our waste

management problems, reduce freshwater pollution from organic wastes, increase fuel security and reduce our dependence on chemical fertilizers.

The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Methanogens, finally are able to convert these products to methane and carbon dioxide.

This process has been used on a large scale especially in Europe for processing of biodegradable waste and the technology has been advanced to a great extent. The biogas generated in the process is used for commercial purposes. The manure is used for improving the fertility of the soil. Germans have developed biogas engines that are quite effective and efficient. Biogas has been compressed in countries like Germany, Sweden and Denmark and such compressed and purified biogas is used for running vehicles. In our country several attempts to adopt this technology have failed especially wherever big projects of large capacities were envisaged. The failures are mainly due to unsuitability of the technology to the type of waste generated in our country. The European plants are designed to handle waste materials that have constant characteristics over number of years. The concept of food processing has matured in that society. The food processing plants are expected to generate uniform type of waste. Once the characteristics of waste to be processed are known, then it is easier to design a plant to handle and process such materials. Such type of resources would rarely contain stones or building materials. In our society, it would still take some more time for setting such high quality standards for a waste processing plant!

Having said all this, we must also realize that anaerobic digestion is the key to the management of solid biodegradable waste materials and a large amount of biomass generated in nature. What we need is adaptation of a suitable technology that will in turn strengthen the anaerobic process. NISARGRUNA is designed for this very purpose.

This technology developed by Bhabha Atomic Research Centre, Mumbai for processing segregated biodegradable waste materials involves combination of aerobic and anaerobic processes. The two phases have been used in series for easing the process and making it sustainable over a period of number of years. Disposal of biodegradable waste can be achieved by trough such decentralized Nisargruna community biogas plants. They would serve many purposes.

1. Environment-friendly disposal of waste that is need of hour considering mass pollution everywhere.
2. Generation of fairly good amount of fuel gas that will definitely support the dwindling energy resources.
3. Generation of high quality manure that would be weed-less and an excellent soil conditioner. This is very important for replenishing fast decreasing resources of productive soils. It must be noted that need for replenishing the soil with high quality organic manure has been identified in tenth five-year plan.
4. They would reduce the menace of street dogs and other nuisance animals.
5. They would help in removing the garbage hills from rural and urban areas and help in achieving the dream of "Garbage free Vasundhara".

Integrated approach: The need of hour is to understand various processes available for degradation of waste materials and ensure the recycling of natural resources. The roadmap we wish to design for this purpose should not be unfriendly to nature. We can adopt composting and vermicomposting for small localities where such processes can effectively be controlled and would solve the problem. The advanced locality management concept developed some years ago in Mumbai Municipal Corporation has offered a good example in this field. Nisargruna biogas plants would help in processing the biodegradable waste from bulk generators like hotels, restaurants, vegetable and fruit markets, temple towns and big colonies. Such decentralized plants would also reduce the stress on transportation of such health hazards through a distance in cities causing environmental and aesthetic problems. They would reduce the overall need for dumping yards. But we must remember that any integrated approach for handling of waste materials will not include incineration in any form, as that is without any doubt, not environment-friendly by any means.

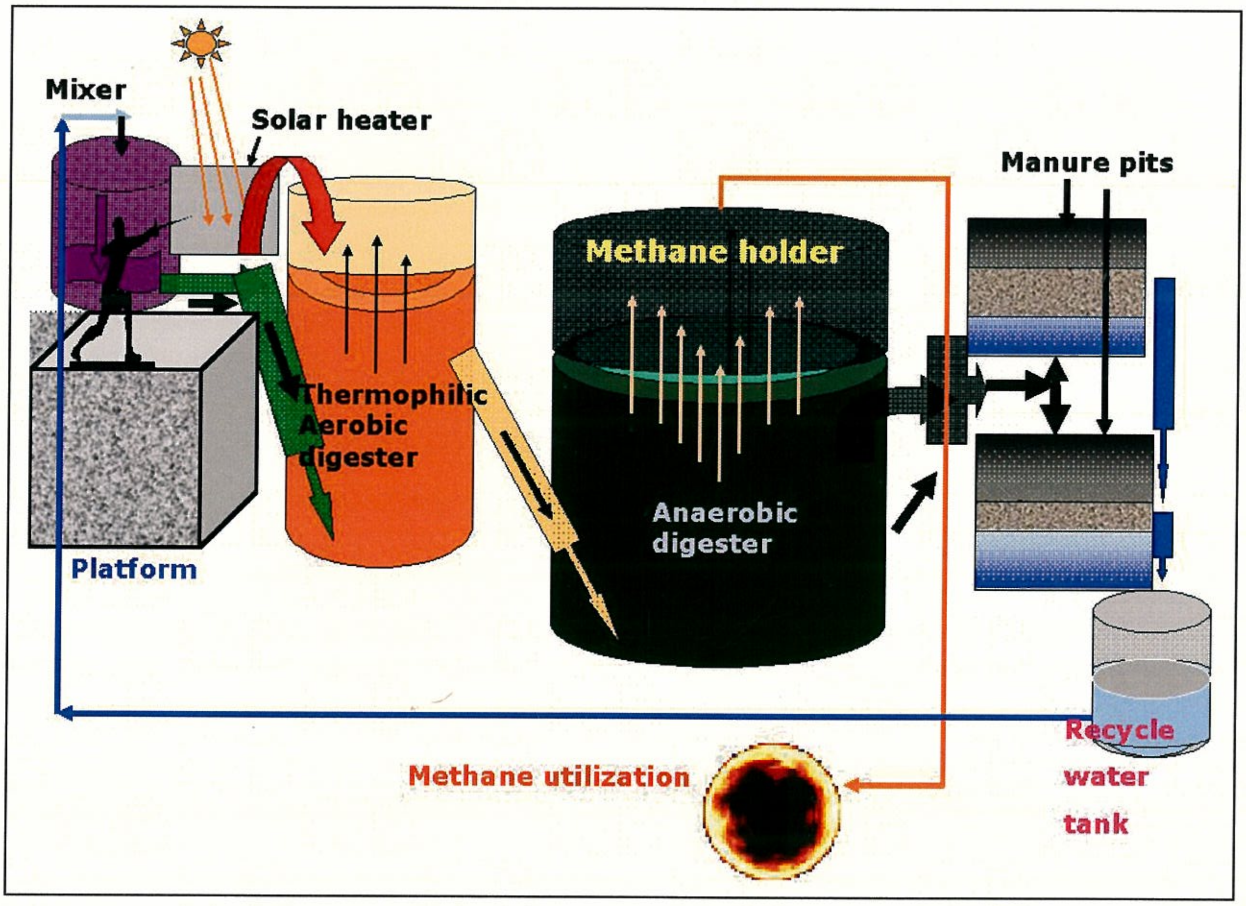
SCIENCE OF NISARGRUNA PROCESS

The waste generated in kitchen in the form of vegetable refuge, stale cooked and uncooked food, extracted tea powder, waste milk and milk products can all be processed in this plant. Based on our understanding of thermophilic microorganisms in particular and microbial processes in general, we have introduced a 3-5 HP mixer to process the waste before putting it into predigester tank. The waste is converted in slurry by mixing with water (1:1) in this mixer. Usually this is the failure point as solid waste is difficult to get digested and can easily clog the system. If we can pulverise the waste in a paste, the digestion is assured. There will be no scum formation and no clogging. The other important thing is use of thermophilic microbes for faster degradation of the waste. The growth of thermopiles in the predigester tank is assured by mixing the waste with hot water and maintaining the temperature in the range of 45-50°C. The hot water supply is from a solar heater. Even few hours' sunlight is sufficient per day to meet the needs of hot water. Alternately, part of biogas generated in the system can be used for getting hot water. It must be remembered that the reactions in predigester are exothermic in nature and only a proportionate quantum of hot water is needed to achieve the results. Their main role is to digest proteins and low molecular weight carbohydrates to produce volatile fatty acids. Ideally there would be two pre-digesters that will receive the waste on alternate days so that undisturbed digestion for about 48 hours will give desirable results.

The same result can be achieved by providing a baffle wall in single predigester. It is mandatory that the effective volume in either case will be the same. The pH of the slurry drops to 4 - 6 due to accumulation of volatile fatty acids. The total soluble solids reduce from 23-25% to 13-15% in this tank. The retention time is between 72 to 96 hours. More retention in predigester than this period would result in loss of biogas and manure in the second phase.

Pre-digestion is extremely important for following reasons:

- Hydrolysis of the waste
- Acidification and formation of volatile fatty acids
- Removal of scum forming components
- Removal of sulphur in the form of sulphur dioxide
- Formation of uniformly flowable slurry to ensure smooth digestion in anaerobic digester



After the predigester tank the slurry enters the main tank where it undergoes mainly anaerobic degradation by a consortium of archaebacteria belonging to *Methanococcus* group. These bacteria are naturally present in the alimentary canal of ruminant animals (cattle). They produce mainly methane from the cellulosic materials in the slurry. As the gas is generated in the main tank, the dome is slowly lifted up. The design of the dome, which floats on a water seal, is such that there is no direct contact between the slurry and the dome. It reaches a maximum height of 4 feet holding biogas. The biogas is a mixture of methane (55-75%), carbon di oxide (40-15%) and water vapours (5-10%). It is taken through GI pipeline to the lampposts. Drains for condensed water vapour are provided on line. This gas burns with a blue flame and can be used for cooking as well. The excess gas is liberated in the atmosphere after the dome reaches maximum height. The utilization of gas should be spaced in such a manner that this release of excess gas is avoided. The main component in biogas is methane (green house gas) and it has a very high negative impact on the environment.

The pressure in the dome is between 100 to 200mm of water column. The pressure is sufficient to take this gas to a distance of about 300-400m without any loss of efficiency. The pressure can be increased by putting additional weight in the form of MS discs or any other suitable and aesthetically acceptable alternative.

The undigested lignocelluloses and hemicelluloses materials then are passed on in the settling tank in the form of finely divided powder. After about a month high quality manure can be dug out from the settling tanks. There is no odour to the manure at all. The organic contents are high and this can improve the quality of humus in soil, which in turn is responsible for the fertility. The manure can be used for nurseries and fields. The manure pits are provided with filtration system that can separate out the water in an underground tank. This water can be reused in the system. The BOD of this water is less than 100-150, which is quite acceptable for reuse in the Nisargruna system. The bucket centrifuge can do the job faster.

Nisargruna technology offers an economically viable option for waste disposal. The savings on transportation of waste materials at dumping yards (considering decentralized nature of Nisargruna plants), moderate earning through gas and manure and possible carbon credits can make the technology very attractive. It would also have impacts on health sector.

HOW THE TECHNOLOGY DIFFERS FROM CONVENTIONAL ANAEROBIC DIGESTER TECHNOLOGY

Nisargruna technology developed for processing of biodegradable solid waste materials generated in kitchens, vegetable market, slaughter houses and animal stables is based on aerobic-anaerobic sequential processes. It offers an excellent alternative for decentralized processing of solid biodegradable waste and avoids the contamination of land-fill sites. It differs from the classical anaerobic digesters in the following aspects.

1. Nisargruna plant has a broader scope to accept a variety of raw materials mentioned above while the anaerobic system developed in our country is mainly used for processing animal dung.
2. Nisargruna technology is a high rate bio-methanation process. It uses a mixer to homogenize the biodegradable waste with water into free flowing slurry.

3. Nisargruna process involves pre-treatment of the homogenized biodegradable waste slurry in an aerobic digester for a limited period (about 3-4 days). This process is accentuated by aeration and higher temperature. The temperature is maintained between 45-50°C using solar energy. The hydrolysis and acidification stages are carried out in this phase.
4. Aerobic phase helps in removing scum forming protein materials. This is a major achievement as scum formation can terminate the entire process.
5. It helps in oxidation of sulphur compounds. Formation of hydrogen sulphide is thereby avoided in anaerobic process and biogas formed is free of this corrosive gas.
6. The temperature in this range (45-50°C) helps in hygienization of the waste. All coli-form bacteria are eliminated due to higher temperature and acidic conditions.
7. There are several structural changes made in anaerobic digester. These changes are intended for smoother particle movement and enrichment of biogas with respect to methane value.
8. The dome structure has been changed to avoid its contact with slurry (which used to be the case in gobar gas technology) thereby ensuring proper entrapment of the biogas.
9. The water coming out of the anaerobic slurry is allowed to settle in settling tanks where filtration is used to remove manure and recycle the water.
10. Thus the plant achieves the dream of "Zero garbage, Zero effluent and Zero energy process" as more energy is generated in the form of biogas than energy spent in the operation of the plant.
11. It has a good potential to generate the employment opportunities in lower strata of the society. The NGOs of such dedicated persons can help in achieving this target.
12. The manure generated in the process is weed-free and rich in organic carbon contents. Hence it will be a better soil conditioner than any other organic manure.
13. The biogas has better fuel value. It can be used for thermal purpose or can be converted to electricity.

14. The technology can be upgraded as per user's requirement. This is especially useful in urban area where large quantities of wastes are generated in relatively smaller places.

ADVANTAGES OF NISARGRUNA TECHNOLOGY

1. Environmental friendly processing of biodegradable waste is achieved. This waste is completely zeroed and by-products are generated.
2. The elemental cycles like nitrogen, carbon, hydrogen, oxygen etc. cycles expect that the biodegradable waste have to go through microbial route for ensuring their availability for future life. Nisargruna achieves this objective fully.
3. The processing cost of biodegradable waste is far lesser compared to any other foreign technology.
4. Decentralized handling of the waste will reduce the transportation costs, dumping yard needs and assured processing. In long run, it means that dumping yards could be totally eliminated. If proper segregation occurs at the source, then the requirement of land-fill sites can be reduced by 60-70%.
5. Transportation of this waste through crowded areas could easily be avoided if decentralized Nisargruna plants are made available.
6. By-products like biogas and manure can make the process economically attractive.
7. Processing of solid biodegradable waste in this manner would ensure that this material wouldn't be carried to dumping yards and release methane there, in slow and unplanned composting. Since the biogas is trapped to burn, the contamination of environment with a vast quantity of methane will be completely avoided. This would earn carbon credit.
8. The use of biogas as fuel will save the classical fuel consumption including petrol, LPG and diesel.
9. In rural areas where biomass can be made available to run these plants, energy-freedom can easily be achieved. The stand-alone Nisargruna plants can be rural powerhouses.
10. In rural areas it will reduce the use of wood as fuel thereby helping indirectly in forestation.
11. The aesthetic looks of the country can be changed using Nisargruna technology.

12. It offers a long-life methodology to treat the biodegradable waste in a very limited space.
13. The technology is relatively simple and does not involve any imports. The plants can be operated by unskilled workers after training them initially for about 3-4 weeks. It is developed keeping in mind local environment and the types of wastes.
14. The manure generated in the process will help in rejuvenating the depleting organic carbon contents in our agricultural soils.
15. The processing of biodegradable waste and making it zero would tremendously improve the hygiene of the country, reduce the epidemics and make people in general healthy. The substantial reduction in health bills is a distinct possibility. It would also influence the human efficiency.

ECONOMICS OF THE PROCESS:

Nisargruna concept offers a technology that helps in

1. Decentralized processing of biodegradable waste
2. Achieving the dream of zero garbage and zero effluent
3. Reduction in transportation costs (Table 1)
4. Reduction in space requirement (Table 1)
5. Maintenance of biogeochemical elemental cycles
6. Generation of by-products which can give financial support and motivation for the operators
7. Employment generation in lower economic strata of society
8. Reduction in dumping yard menace
9. Quality improvement in dry waste as the wet and degradable portion is removed from that.
10. Benefits in carbon credits
11. Benefits in health sector

MEMORANDUM OF UNDERSTANDING

All India Institute of Local Self Government (AIILSG), Mumbai had organized a workshop at Matheran in January 2004 wherein various methodologies for handling Matheran waste were discussed. It was attended by various government officials. It was decided unanimously that Nisargruna technology developed by Bhabha Atomic research Centre (BARC) may be adopted by Matheran Municipal Council (MMC) for this purpose. A formal request for financial assistance was forwarded by Chief Officer of MMC to Mumbai Metropolitan Region Environment Improvement Society (MMR-EIS) for setting up a Nisargruna plant at Matheran and another letter was sent requesting the technological cooperation to BARC. A formal Memorandum of understanding (MOU) was then signed between these three organizations (MMC, BARC and MMR-EIS) in March 2005. The copy of this MOU is attached herewith. Accordingly work was initiated in April 2005. Matheran being an ecosensitive zone, there are many restrictions imposed in this zone by environmental authorities. No vehicle is permitted in Matheran. Hence all the transportation is to be done either by horse or handcarts for a distance of about 3.5 km. The toy train helps in transportation of certain materials. However during the period of Nisargruna construction, this train was not functioning due to landslides after 26th July 2005 downpour for a period of 18 months. All the construction of Nisargruna plant took place during this period only. There are no excavators nor use of dynamite is permitted for excavation. Hence all the work had to be manual. In Matheran the fury of monsoon lasts for four months. The progress of work during monsoon is extremely slow. The fabrication of dome was another challenge. There are no cranes to lift the heavy materials. The weight of dome is about 3 MT distributed over span of 7.9m diameter area. All the fabrication was done at the site and dome was placed in the well using chain pulleys. Some photographs are attached herewith. These are various reasons for the delay in construction. The plant became ready in January 2007 and functional in February 2007. Since then it is functioning in an uninterrupted way till the date.

PROJECT DETAILS

The Nisargruna plant is located in the premises of Matheran Municipal Council. The address is as follows: Plot No. 153/A, City Survey Number 252, Near Municipal Hospital, Matheran. The land ownership is of Matheran Municipal Council. The plant is occupying an area admeasuring of about 500 square meters. It is surrounded by trees. While construction no trees were disturbed. The GPS location of the plant is as follows:

According to Global Positioning system physical location of the site is as shown in Table 3.

Table 3: GPS Location of Nisargruna biogas plant at Matheran

Sr. No.	**Reference No.**	**Location**
1	Digester	N18^{0}58.904′ E073^{0}16.127′
2	Manure pits	N18^{0}58.898′ E073^{0}16.129′
3	Platform	N18^{0}58.899′ E073^{0}16.125′

Table 4: Expenditure for Civil, mechanical and electrical works

S. No.	Item	Quantity	Cost	Total
1	Compressor (3 HP)	1	40, 000	40, 000
2	Compressor (1 HP)	1	30, 000	30,000
3	Mechanical mixer (5 HP)	2	64, 000	1, 28, 000
4	Mechanical dome	1	3, 40, 000	3, 40, 000
5	Roof structure	1	1, 35, 000	1, 35, 000
6	Water pump	2	20,000	20, 000
7	Construction Materials			15, 34, 208
8	Labour			6, 22, 000
9	FRP for dome			30,000
10	Culture seeding	10mt	2000	20,000
11	Grand total			28,99,208

DEVELOPMENT OF OPERATION MANUAL FOR NISARGRUNA

The procedure involved in obtaining ISO 9000 certification has considerably helped in evolving the technology further. The team handling the NISARGRUNA biogas plant at Matheran is very dedicated. They have been running this plant for last 20 months without any breakdown or stoppages of any kind. This experience is very encouraging for various chief officers from different parts of the State. They start asking themselves, "If Matheran Council can do it, why not we?" This confidence level will be very important for propagating this technology on a very wide scale. The continuous efforts of Nisargruna operators at Matheran have helped in designing an operation manual in Marathi.

निसर्गऋण प्रकल्प

कार्यप्रणाली व सूचना

ओला कचरा वेगळा गोळा करून मग त्याची पर्यावरणानुकूल पध्दतीने जर तिथल्या तिथेच विल्हेवाट लावली तर निसर्गाचे ऋण आपण योग्य त्या मार्गानेच अंशतः तरी फेडल्याचे समाधान आपल्याला लाभेल याची खात्री वाटतें त्या शिवाय या पध्दतीचा आणखी महत्वाचा फायदा म्हणजे ओला कचरा फारसा दूर वाहून न्यावा लागणार नाही, रस्त्यावरुन तो नेत असतांना होणारे प्रदूषण टाळता येईल, व वाहातूकीसाठी होणारा खर्च कमी होईल आणि कच-यातून संपत्ति निर्माण करण्याची संकल्पना प्रत्यक्षात आणता येईल. ओला कचरा म्हणजे साधारणतः स्वयंपाक घरात निर्माण होणारा कचरा असे म्हंटले तरी चालेल. यात शिळे व खराब झालेले अन्न, फळांच्या साली, भाज्यांमधील टाकाऊ भाग, खरकटे, पानात टाकून दिलेले पदार्थ इत्यादी गोष्टींचा समावेश करता येईल. या कच-याची योग्य विल्हेवाट लावली नाही तर अनारोग्याचा धोका संभवतो. या प्रकल्पात ओल्या कच-यापासून आपल्याला निसर्गज्योति (methane) हा इंधनवायु व उत्तम प्रतीचे सेंद्रिय खतही मिळते.

विविध उपाहारगृहात, भाजीमंडई मधे वा घराघरात निर्माण होणारा ओला कचरा या प्रकल्पावर आणला जातो, तिथे त्यातील प्लास्टिक, अंडयांची टरफले व नारळाच्या करवंटया वेगळया काढून मग तो कचरा एका मोठया मिक्सरमधून फिरविला जातो. त्यावेळी त्यात थोडे पाणी मिसळून त्याचे एकजीव मिश्रण बनते. हे मिश्रण एका मोठया भूमिगत टाकीत जाते. या टाकीत योग्य प्रमाणात गरम पाणी मिसळले जाते. हे गरम पाणी मिळविण्यासाठी सौरउर्जेचा वापर केला जातो. या टाकीतून मग हे मिश्रण आणखी एका मोठया भूमिगत टाकीत सोडले जाते. या टाकीत प्राणवायू विरहीत वातावरण राखलेले असते, तिथे येणा-या मळीपासून निसर्गज्योति ह्या

इंधन वायु निर्मितीची प्रक्रिया पूर्ण क्षमतेने करणारे जीवाणू कार्यरत असतात. तयार होणारा निसर्गज्योति हा इंधनवायु त्या टाकीवर खालीवर होणा-या टोपामधे जमा होतो. ही प्रक्रिया जसजशी पूर्ण होत जाते तसतसा मळीतील उरलेला भाग मग खताच्या स्वरूपात उघडया टाकीत पाठविला जातो याचा वापर शेतीसाठी किंवा बागेसाठी करता येईल.

सर्वसाधारणपणे प्रत्येक निसर्गऋण प्रकल्पात ओला कचरा खतात रुपांतरित होईपर्यंत १९ ते २० दिवसांचा कालावधी लागतो या कालावधीचा विचार करुनच या प्रकल्पाची रचना केलेली आहे. यामुळे एकदा सुरु झालेला प्रकल्प अव्याहतपणे चालत राहील. मात्र त्यासाठी खालील बाबींवर लक्ष केंद्रित करावे लागणार आहे.

निसर्गऋण प्रकल्पाच्या आस्थापनेमध्ये कामगार व एक निरिक्षक असणे गरजेचे आहे. कामगारांची संख्या ही निसर्गऋण प्रकल्पाच्या क्षमतेवर अवलंबून असेल. सर्वसाधारणपणे एक मेट्रिक टन ओला कचरा हाताळण्यासाठी दोन कामगारांची गरज असते. अधिक क्षमतेच्या प्रकल्पांसाठी खालील तक्त्यात दर्शविल्याप्रमाणे कामगार असावे लागतील.

प्रकल्प क्षमता (मेट्रिक टन प्रति दिन)	कामगारांची संख्या
२ ते ३	३
४ ते ५	५
६ ते ८	६
१०	८

प्रत्येक निसर्गऋण प्रकल्पावर प्रकल्प नियंत्रणासाठी एक नोंद वही असेल. या नोंदवही मध्ये निरिक्षकाने दैनंदिन घडामोडींची सविस्तर माहिती लिहावयाची आहे. प्रकल्प चालवितांना आलेल्या अडचणींची नोंद करुन त्यावर केलेल्या उपाययोजनांसंबधीची माहिती देखील या नोंद वहीत लिहिणे अपेक्षित आहे.

निसर्गऋण प्रकल्पाच्या निरिक्षकाने करावयाची कामे

- निसर्गऋण प्रकल्पावर तो कार्यान्वित झालेली तारीख, त्याची क्षमता व तो हाताळणारी संस्था दर्शविणारा नामफलक लावलेला असला पाहिजे.
- निसर्गऋण प्रकल्पावर निरिक्षक, कामगार व वरिष्ठ अधिकारी यांची नावे व संपर्कासाठी चे पत्ते, दूरध्वनी व भ्रमणध्वनी क्रमांक लिहिलेला फळा सहज दिसेल व सहजपणे वाचता येईल अशा पध्दतीने लावलेला असावा.
- सकाळी आल्याबरोबर सुरक्षा रक्षकाकडून प्रकल्पाचा ताबा घेतांना त्याच्या अहवाल घ्यावा.

- त्यातील महत्वाच्या बाबींची नोंद लगेचच नोंद वहीत करावी व त्या खाली सही करावी.
- जर एखाद्या बाबीवर विचार विनिमय करावयाचा असेल तर तातडीने योग्य त्या वरिष्ठांशी संपर्क साधावा व त्यांनी दिलेल्या सूचनांची नोंद वहीत करुन त्याप्रमाणे उपाय योजना करावी व ती उपाय योजना झाल्यानंतर त्याची माहिती पुन्हा त्या वरिष्ठांपर्यंत पोहोचवावी.
- निसर्गऋण प्रकल्पावर निरिक्षण फेरी पूर्ण करावी व त्यात काही अनियमितता दिसली तर त्याची नोंद करुन त्यावर योग्य ती उपाययोजना करावी. सुरक्षा रक्षकाला त्या नंतरच कामावरुन घरी जाऊ द्यावे.
- कामगारांच्या हजेरीची नोंद करुन त्यांना कामे द्यावीत.
- कामगारांना लागणारी उपकरणे व वस्तू उपलब्ध आहेत याची खात्री करुन घ्यावी व त्या उपकरणांची कार्यप्रणाली नीट चालू आहे याचीही खातरजमा करावी.
- प्रत्येक कामगार सुरक्षा उपकरणांचा व सुरक्षा नियमांचे पालन कसोशीने करीत आहे की नाही यावर बारीक लक्ष ठेवावे. जर एखादा कामगार तसे करीत नसेल तर त्याची समज संबंधित कामगाराला देऊन त्यासंबंधीची नोंद वहीत करावी. वारंवार जर असे घडत असेल तर त्याची माहिती वरिष्ठांना देऊन त्यावर सांगितलेली कारवाई करावी.
- ओला कचरा आल्यानंतर त्याची नोंद करुन घ्यावी जर वर्गीकृत होऊन हा ओला कचरा येत नसेल तर ते वरिष्ठांच्या नजरेस लगेचच आणून द्यावे. त्यासंबंधी दोनदा समज देऊनही असे घडले तर तो कचरा स्वीकारु नये व संबंधित खात्याला लगेचच ते कळवावे.
- ओला कचरा वर्गीकृत करुन व वजन करुनच मिश्रकात टाकावा व त्यात पाण्याचे प्रमाण १:१ एवढे राखले जात आहे यावर लक्ष ठेवावे.
- मिश्रकाचे व्ही पटटे व्यवस्थित कार्य करीत आहेत याकडे लक्ष द्यावे.
- मिश्रक चालू असतांना पहिल्या टाकीतील हवेचा पुरवठा बंद ठेवावा.
- मिश्रक चालू असतांना माशा व इतर त्तसम कीटकांचा त्रास होऊ नये म्हणून लावलेला दिवा चालू करावा त्या दिव्याची स्वच्छता होत आहे ना याकडे लक्ष द्यावे.
- काम संपल्यानंतर हवेचा पुरवठा पुन्हा सुरु करावा व तो सातत्याने चालू राहील या दृष्टीने दाबाने हवा पुरविण्याच्या यंत्राचा (Air Compressor) योग्य तो वापर करावा.
- जैव वायु निर्मिती च्या टाकी भोवताली असलेले पाण्याच्या आवरणात पाणी स्वच्छ व पुरेसे आहे याची खात्री करावी.
- त्या पाण्यात डास होऊ नये म्हणून त्यात थोडेसे तेलाचे थेंब टाकावेत.
- जैव वायुचा योग्य तो वापर होत आहे याची काळजी घ्यावी व ते मोजण्यासाठी लावलेल्या वायुमापकाचे काम नीट चालले आहे याची खातरजमा करुन घ्यावी.

- खत खडडयांमधील पाण्याचे पुनर्चक्रांकण नीट होत आहे ना, त्यासाठी असलेला पंप कार्य करीत आहे ना या कडे लक्ष पुरवावे.
- प्रकल्पावरील विद्युतपुरवठा व पाणी पुरवठा व्यवस्थित ठेवावा त्यासाठी आवश्यक असलेल्या उपकरणांची काळजी वेळच्यावेळी घ्यावी.
- खत खडडयांमधे खत जमा झाले असेल त्यावेळी ते खत काढण्याची व्यवस्था करावी
- सर्व काम पूर्ण झाल्यानंतर त्याकामासंबंधीच्या महत्वाच्या नोंदी नोंदवहीत कराव्यात व ज्या बाबींकडे ताबडतोब लक्ष देणे गरजेचे आहे त्यासंबंधी योग्य ती उपाय योजना करावी.
- कामाचा दैनंदिन अहवाल संबंधित वरिष्ठांना व मासिक अहवाल भाभा अणुसंशोधन केंद्राकडे सादर करावा.
- प्रकल्पासाठी लागणा-या वस्तूंचे व उपकरणांचे मागणीपत्र विहित नमुन्यात संबंधित वरिष्ठांना वेळेवर सादर करावे म्हणजे वेळेतच त्याचा पुरवठा होऊ शकेल.
- उपकरणंच्या दुरुस्तीसाठी आवश्यक त्या उपाययोजना कराव्यात, त्यासाठी आवश्यक असेल तिथे वार्षिक करार करावेत व त्या कराराची अंमलबजावणी होत आहे की नाही याची काळजी घ्यावी.
- खताचे व जैव वायुचे रासायनिक विश्लेषण नियमित वेळी विश्वासार्ह प्रयोगझाळांकडून करुन घ्यावे व त्यात अनियमितता आढळली तर संबंधित वरिष्ठांषी संपर्क साधावा.
- जर नियमित कार्यप्रणालीत अडचणी आल्या तर लगेचच संबंधित वरिष्ठांशी संपर्क साधावा.
- खत खडडयांमधील पाण्याचे विश्लेषण देखील ठरावीक कालावधींनंतर करुन घ्यावे व त्यासंबंधीचा अहवाल दप्तरी ठेवावा.
- प्रकल्पाला भेट देणा-या लोकांना प्रकल्पासंबंधी माहिती देऊन त्यांच्या प्रतिक्रियांची नोंद त्यासंबंधी ठेवण्यात आलेल्या पुस्तिकेत करण्याची त्यांना विनंति करावी.
- जर प्रकल्पासंबंधी कुणाची तक्रार असेल तर त्यासाठी एक तक्रारवही प्रकल्पावर ठेवावी व त्यात नोंदलेल्या तकारी दूर करण्यासाठी योग्य ती उपाययोजना करावी.
- सरकारी अधिका-यांनी वा इतर लोकांनी दिलेल्या सूचनांची दखल घेतांना त्यासंबंधी वरिष्ठांची संवाद साधणे जरुरी आहे.

निसर्गऋण प्रकल्पाच्या कामगारांनी करावयाची कामे

- निरिक्षकाने दिलेल्या सूचनांचे काटेकोरपणे पालन करणे.
- काम करीत असतांना त्यासाठी नेमून दिलेला गणवेषच घालावा व सुरक्षा सामग्रीचा वापर करावा.
- या वस्तूंमधे त्रुटी आढळल्यास ती बाब निरिक्षकाच्या नजरेस आणून द्यावी.

- ओला कचरा हाताळतांना हातात योग्य ते हातमोजे घालावेत व तोंडाला रक्षक-कवच लावावे.
- ओला कचरा हाताळतांना विद्युत पुरवठा सुरू करण्याच्या वेळी आवश्यक ती काळजी घ्यावी म्हणजे विद्युत धक्का बसणार नाही.
- ओला कचरा हाताळतांना त्यात असलेल्या कठीण (म्हणजे नारळाच्या करवंटया, अंडयाची साले, चमच्यांसारख्या धातुंच्या वस्तू, खडे, दगड) व प्लास्टिकचे पदार्थ वेगळे करावेत व ते मिश्रकात जाणार नाहीत याची काळजी घ्यावी.
- ओला कचरा हाताळतांना त्यात टाकले जाणारे पाणी नियंत्रणात ठेवावे.
- ओला कचरा हाताळल्यानंतर म्हणजेच काम पूर्ण झाल्यानंतर प्रथम डेटाल व फिनेल चा वापर करुन फलाट स्वच्छ करावा व त्यानंतर हात व पाय साबणाने स्वच्छ धुवावेत.
- ओला कचरा हाताळतांना काहीही खाऊ अथवा पिऊ नये.
- खत खडडयांमधील पाण्याचे पुनर्चक्रांकण करुन शक्य तेवढया जास्तीत जास्त त्याच पाण्याचा वापर या प्रकल्पात करावा.
- खत खडडयांमधील खत काढतांना वाळू व दगड असलेली गाळण प्रणाली अबाधित राखावी.
- खत सुकवितांना ते उन्हात न सुकविता सावलीत ठेवावे म्हणजे त्यातील पोषणमूल्य कमी होत नाही.

OPERATION OF NISARGRUNA BIOGAS PLANT FROM MARCH 2008

NISARGARUNA BIO-GAS PROJECT WASTE PROCESSING MONTHLY REPORT

NO.	PERIOD	WET WASTE COME FOR PROCE SSING	FEEDING		MIXED HOT WATER
	Month		BIO DEGRADABLE WASTE	MIXED RECYCLABLE WATER	
		MT	MT	L	70-80 C
1	Mar-07	33.80	0.00	0.00	0.00
2	Apr-07	34.20	0.00	0.00	0.00
3	May-07	35.50	0.00	0.00	0.00
4	Jun-07	24.70	0.00	0.00	0.00
5	Jul-07	20.40	0.00	0.00	0.00
6	Aug-07	78.00	73.90	66490.00	12600.00
7	Sep-07	70.25	66.15	59360.00	11700.00
8	Oct-07	90.50	86.14	77330.00	13270.00
9	Nov-07	89.75	82.02	76495.00	13500.00
10	Dec-07	94.00	86.37	80550.00	13530.00
11	Jan-08	94.00	86.37	80550.00	13530.00
12	Feb-08	97.50	89.66	83435.00	13300.00
13	Mar-08	94.00	86.37	80550.00	13530.00
14	Apr-08	89.25	85.19	76480.00	12870.00
15	May-08	105.50	97.05	89940.00	14070.00
16	Jun-08	98.75	90.76	84395.00	13550.00
17	Jul-08	83.25	79.30	71285.00	12800.00
18	Aug-08	83.50	79.27	71005.00	12200.00
19	Sep-08	69.50	65.20	58560.00	11800.00
20	Oct-08	85.00	80.29	72105.00	12970.00
21	Nov-08	102.75	94.84	87610.00	14930.00
22	Dec-08	0.00	0.00	0.00	0.00
	TOTAL	1574.10	1328.88	1216140.00	210150.00

ANALYSIS OF VARIOUS NISARGRUNA PARAMETERS

The feed which is processed in the Nisargruna biogas plant is actually of plant or biological origin. The three major constituents of any living matter are proteins, carbohydrates and lipids. The food value of the material is decided by the proportion of these three components. The whole process of degradation is a direct function of microbial activities in pre-digester and digester. The sequential degradation of biodegradable waste in these two digesters will effectively determine the biogas and manure generation and overall efficiency of the process. Hence it is important to analyze the samples periodically to judge their potentials. Matheran biogas plant is mainly fed by kitchens of various hotels in this hill station. Horse dung is another major component of the waste received on the plant. The samples were analyzed periodically and average values are given here.

ESTIMATION OF CARBOHYDRATES

NAME OF THE METHOD: ANTHRONE METHOD

Requirements:

a) 2.5N HCl: 2.5gm of Conc. HCl in 50 ml of distilled water.

b) Anthrone reagent: dissolve 200mg of anthrone in 100 ml of ice-cold 95% H_2SO_4 (freshly prepared)

c) Standard glucose solution: Stock- 100mg/100ml. Working standard solution: 10ml of stock diluted to 100ml with D/W. (i.e. 100ug/ml)

d) Diluents: D/W.

Procedure:

Sample preparation: Take 100mg of sample and add 5 ml of 2.5N HCl. Keep in Boiling water bath for 3 hrs. Cool at room temperature. Neutralize with Na_2CO_3 until the effervescence ceases. Make the volume up to 100ml with water and use the supernatant for estimation. Cool all the tubes rapidly and mix the contents of the tubes. Measure absorbance at 630nm. Note. Cool the contents of all the tubes on ice before adding ice-cold Anthrone reagent. Plot the graph of concentration of glucose in µg/ml against absorbance at 630 nm. Extrapolate the values of absorbance of unknown on the straight line and determine the concentration of carbohydrate in the given sample.

ESTIMATION OF PROTEINS:

NAME OF METHOD: BIURET METHOD.

Requirements:

Standard protein stock solution: Bovine serum albumin (10mg/ml)

Diluents: Distilled water

Reagents: 2.5% $CuSO_4$: 3N NaOH

Sensitivity Range: 0 – 10 mg/ml

Sample preparation: Take 1gm of solids and mix with 3N NaOH (in case of wet sample 10 ml is taken and in case of dry sample 20 ml is taken). Warm in a water bath for five minutes and process according to the protocol. Plot the graph of concentration of standard protein in mg/ml against absorbance at 530 nm. Extrapolate the values pf absorbance of unknowns on the straight line to obtain the values of protein in the sample.

ESTIMATION OF LIPIDS

10g of dried sample was packed in a Whatman filter paper and fitted into a connector of Soxhlet apparatus. Lipids were extracted in this apparatus using acetone as a solvent. The lipids were estimated by weighing the sample in the extract after evaporating the solvent.

DETERMINATION OF SOLIDS

Solids in the sample are determined in order to track the process of degradation in the NISARGARUNA BIOGAS PLANT, as gradual reduction in concentration of total solids can be conveniently correlated to the microbial degradation of materials. Sample is used for the determination of total solids, volatile solids and fixed solids.

Determination of Total, Volatile and Fixed solids-

Apparatus-

a) Evaporating dish- 90 mm diameter, made up of porcelain.
b) Drying oven, for operation at 105°C.
c) Muffle Furnace for operation at 550°C.
d) Desiccators.
e) Analytical balance.

Procedure-

A) Preparation of evaporating dish- A clean evaporating dish is ignited at 550°C for 1 hr in a muffle furnace and stored in a desiccator for cooling, until ready for use. The dish is weighed just before use.

A) Sample analysis- 25 gm of sample is placed in a prepared evaporating dish and weighed. The sample is evaporated to dryness on a water bath and then dried at 105oC for 1 hr. The sample is cooled in a desiccator and weighed. The sample is transferred to a cool muffle furnace and the furnace is heated to 550oC and ignited for 1hr. The sample is then cooled in a desiccator to balance temperature and weighed.

Calculations-

% total solids = (A-B)*100/(C-B)

% volatile solids = (A-D)*100/(A-B)

% fixed solids = (D-B)*100/(A-B)

Where:

A= Weight of dried residue and dish, mg,

B=Weight of dish, mg,

C=Weight of wet sample and dish, mg,

D=Weight of residue and dish after ignition, mg.

Table 6: Estimation of proteins, carbohydrates, lipids and total solids in raw and pre-digested slurry

Day	Total solids (TS) %		Lipids % of TS		Carbohydrates % of TS		Proteins % of TS	
	Raw	PD	Raw	PD	Raw	PD	Raw	PD
1	23.48	13.73	5.33	4.50	6.2	3.9	9.3	3.6
2	24.76	14.82	7.5	6.1	6.1	4.0	9.2	4.4
3	25.28	14.82	8.2	5.8	7.2	4.3	9.0	4.1
4	24.24	13.93	6.83	5.31	6.7	3.74	8.89	3.97

It is evident from this table that pre-digestion stage is very essential for the successful operation of this plant. It helps in reducing the quantity of total solids which reach the main digester and increase the quantities of volatile fatty acids. This type of pre-digested slurry then effectively undergoes further degradation in the anaerobic digester where biogas formation takes place. In absence of pre-digestion, the scum formation would have blocked the digester within a short span of time. Even after processing more that 1600 MT of biodegradable waste in Matheran plant, the digesters have not got blocked even once. The routine examination indicates that the flowability of the slurry in both pre-digester and digester is not affected by presence of un-dissolved solids at any stage. The aeration, hot water and bacteria are the three forces that act in pre-digestion making the slurry more amenable for degradation.

Analysis of organic manure obtained as a by-product in the Nisargruna process:

Estimation of water holding capacity (WHC)

Table 7: Analysis of manure from Nisargruna plants at different locations for their WHC

S. No.	Place	% WHC
1	Govandi	175.3
2	Deonar	257.8
3	Anushaktinagar	185.6
4	BARC	177.7
5	INS Kunjali	160.8
6	Matheran	197.8

WHC is a measure expressing the ability of such manures, which they impart, to soils for holding more moisture over a longer period of time. All the above results indicate that the manure obtained in Nisargruna biogas process is having very good WHC and will help in retaining soil moisture wherever it is used as an amendment.

Elemental analysis of Nisargruna manure

Table 8: Elemental analysis of Nisargruna manure

Element	C	N	P	K	Cd	Cr	Ni	Pb	Co	Mn	Fe	Cu
%	22	2-3	1-1.2	0.5-0.8	nd	nd	0.01	0.01	0.01	0.1	0.1	0.2

nd: not detected (below detection limit)

The wet slurry is quite rich in nitrogen and other essential elements. Hence if it can be used directly without drying, it would yield maximum positive results. As the manure goes on drying, it becomes poorer in nitrogen contents and its efficiency goes on decreasing.

ANALYSIS OF BIOGAS

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Analysis of recycled water

Water obtained after dewatering the manure is recycled into the biogas plant and used for mixing with raw waste. This recycled water was analyzed for its biological oxygen demand (BOD). Microbiological analysis of this water with respect to total bacterial count, total fungal count and presence of coli-form bacteria was also done periodically. The average BOD of recycled water was 60-80 mg/L. The total bacterial count was 18.9 X 10^4 while total fungal count was zero. No coli-form bacteria were detected either in manure or recycled water indicating that Nisargruna process assures complete hygienization.

Analysis of digester and pre-digester gases

Table 9: Gas analysis of pre-digester, digester and manure samples during a day

Time	Gas %	Pre-digester			Digester	Manure slurry
		I	II	III		
1145 hours	**CH_4**	03.0	2.9	7.9	**71.1**	--
	CO_2	05.4	5.4	7.9	14.6	--
	O_2	17.1	16.9	15.1	00.2	--
	N_2/H_2O*	74.5	74.4	71.2	15.2*	--
1245 hours	**CH_4**	3.7	3.7	6.3	**75.6**	2.2
	CO_2	5.7	5.6	7.7	12.5	1.0
	O_2	16.3	16.3	15.5	0.00	18.5
	N_2/H_2O*	74.3	74.5	70.6	13.2*	78.4
1430 hours	**CH_4**	2.8	3.0	8.2	**78.5**	2.2
	CO_2	5.5	5.5	5.6	10.1	0.3
	O_2	16.8	16.8	13.3	00.0	18.8
	N_2/H_2O*	74.8	75.0	72.3	11.8*	78.9

The separation of aerobic and anaerobic phases in pre-digester and digester has resulted in enrichment of methane component in biogas. A small quantity of methane in aerobic emissions in a very limited period indicates the potential dangers of composting processes. Composting, even if done by aerobic methods will result in production of substantial quantities of methane. Since that is not trapped, it will escape in the environment causing green house effects. Hence the importance of bio-methanation thorough Nisargruna process is underlined.

CONCLUSIONS

Solid waste management is the responsibility of Urban Local Bodies in India. However, the issue appears to have gone out of their control due to population explosion, lack of definite policy and non-cooperation from the society in general. If individual households could segregate their waste matter, the problem will be minimized and resource generation will be easier. We have converted a decentralized problem into centralized one because of lack of civic sense in general. Nisargruna biogas plant at Matheran appears to provide a solution of some kind to this problem. The biodegradable waste generated in the premises of Matheran Municipal Council premises is processed for last 8 months. So far 1500 MT of biodegradable waste has been successfully processed and converted into biogas and manure. A gas meter has been installed in this month and we have used 1000 m^3 of gas in last 25 days. This is only partial combustion and it will be improved once end user starts using it.

EPILOGUE

As the world continues to develop, there are increasing demands for energy and, with that; we are now seeing some new issues and tensions arise. Nowhere are these more salient than in this region that has enjoyed unprecedented growth in recent decades. No region has prospered as rapidly as emerging Asia during this period, and because of that energy demand growth has also been very strong. With this increasing need for energy, the oil prices are skyrocketing in the near past. Oil subsidy bills in India are giving nightmares to any responsible citizen of the country. The government finds itself in an un-envious position and it is not easy to wriggle out of this situation.

The access to adequate and affordable energy is one of the basic requirements for guaranteeing the wellbeing and development of rural populations on a sustainable basis. Nearly two billion people, mostly in rural areas of developing countries, are without electricity and rely on burning fuel-wood for their household activities.

Our school curricula include topics on non-conventional sources of energy. Solar energy, bio-energy, wind power, geothermal energy and wave energy are regarded as non-conventional. However, that is the biggest mistake we have made in our understanding of science and nature. Let us consider solar energy. The sun is the oldest source of energy. Our very existence is a result of solar energy. How does that make it non-conventional? The same is true of wind energy, bio-energy and other 'non-conventional' energy sources. To us, coal and petroleum are conventional. And as convention, we use them indiscriminately. The whole logic of nature behind forming these substances was the trapping of excess carbon dioxide, which, as we are finding out, is highly detrimental to the planet. So the carbon dioxide which nature so painfully trapped over long periods of time has been expelled in what feels like one short moment. The result is here for everyone to see and suffer. And the solution is nature's to offer. We need to stop stifling our planet, and we need to do it now. But then how can we continue our great ventures and run our comfortable lives? What we need is a good replacement to 'convention'; a replacement that suits us and helps nature.

While we are trying to put our basics right, we will have to deal with mindsets that would be difficult to change. These mindsets have developed over last hundred years when easy sources of energy were available. These energy sources have set certain norms of usage and costing patterns. These norms may not hold for bio-energy or solar energy. However, we will have to convince one and all and set new norms to start using the renewable and new natural energy sources. The job is very difficult but we will have to undertake it for the very existence of our beloved planet - Mother Earth".

The concept of renewable energy could not gather speed as would have been expected in light of oil crisis all over the world. Developing countries like India could not afford the initial vast investments required in renewable energy projects. Waste may not be a likable item for anyone, but its handling can be a real thorny issue for our city planners. Here the country needs a different approach. We will have to be non-conventional in our thinking, without being illogical, to make renewable sources as our conventional energy means. The famous scientist Dr. Carver had said "Society finds it difficult to change the routine approach towards life. The change should come in such a way that people should not even know that they have changed."

Bio-energy includes all energy produced from biomass, from living organisms of biological origin. Biomass is a locally available energy source that can provide electricity, heat and power. Bio-fuels include solid, liquid or gas fuels derived from biomass and can be divided into four categories: wood-fuels; agro-fuels; municipal waste and fisheries by-products.

Today's bio-energy technology can be used to generate electricity while decreasing emissions of harmful pollutants and greenhouses gases. However, individual bio-energy sources can have widely varying environmental effects. Advanced fuels and technologies are being developed that significantly reduce bio-energy emissions, positioning bio-energy as a key contributor to a sustainable energy future worldwide.

A major constraint in wide scale acceptance of biogas in the society is probably mental attitude rather than its energy value. Especially in our country, the term biogas is closely associated with gobar gas. Gobar gas units have actually played an important role in village economy in seventies and eighties. Even today one can find some excellently run gobar based biogas plants in several parts of the country. However it could not become our flagship renewable energy scheme mainly because of lack of research and development of the process. Inputs from engineering aspects brought some better models like Deenbandhu, fixed dome, KVIC floating dome etc. However the scope remained very limited as only gobar could be processed in such plants in sustainable manner. The weaker biogas flame, reduced animal holdings and therefore unavailability of gobar and generally lack of maintenance, resulted in reduced number of active plants. Europe, on the other hand, saw phenomenal increase in biogas units mainly because of organized research and developmental efforts. In many European countries, vehicles are run on biogas. What an irony then that several companies in Europe are trying to sell their technology in India!

The fertile Indian soils have fed millions and millions of people since time immemorial. Ours has been known as an agricultural country all over the world. India is also blessed with a good amount of forest cover. Yet all is not well in this prime discipline, which faithfully continues to serve us. Another quote of Dr. Carver tells us that the future of the country is safe only if the top soil layer is safe. A continuous exploitation of our soils over several thousands of years has caused depletion of organic carbon. Organic carbon is the soul of fertile soil. The chemical fertilizers can only supplement the soil; they cannot build the soil. Excess and untimely applications of such fertilizers have proved detrimental in many areas and the top soil layer has been irreversibly damaged. Excessive irrigation has also significantly contributed to this loss. Such soils will be sick and will not be able to provide any protection to the standing crops. In the era of highest population becoming higher every day, this is a cause of serious concern. The only solution is replacement of this soil layer by the organic matter. Organic matter can build our soils in a sustained fashion.

The question is where to get the enormous quantities of organic matter? We can produce these large quantities in our own country using only indigenous resources. The concept of bio-energy can provide us both energy and valuable manure. Nature has shown us an excellent way of harvesting solar energy through biological route. Every living cell is an energy powerhouse. Directly or indirectly it uses solar energy. Every bio-molecule is loaded with energy. We use this energy to drive our lives. When plants make food for us either through their grain or fruit, they also generate a large quantum of energy in paraphernalia like leaves, fruit skins etc. These paraphernalia if handled properly can provide us a viable option of harvesting that energy. This route of harvesting energy through NISARGRUNA concept also ensures that we get an energy rich soil conditioner. This will help in replenishing the depleting topsoil layer providing us sustainable and dynamic soil matrix to fulfil our food demand. The route also ensures the continuation of biogeochemical cycles of various elements. Indian farmland extends to about 142 million hectares. Each hectare needs about 2-3 MT of good quality organic manure per year. If we will be able to provide organic manure in such large quantities, we can all eat organic food. This will also help to reduce substantially the use of chemical fertilizers. The effects will be long lasting. We can also harvest huge energy from such Nisargruna biogas plants. A rough estimate to produce this large quantity of organic manure would be about 260000 Nisargruna plants of 50 MT/day. These plants will produce about 100000 MW decentralized energy, which is equivalent to almost 80% of the country's energy needs. The biomass required to run these large number of plants can come from sparing about 15-20% of the cultivable land for this purpose only, in addition to available agro residues. The overall increase in yields of all crops due to good quality of organic manure would compensate easily for this land use. These plants would generate a large number of employment opportunities.

While generating such a large energy using biological resources, we can earn carbon credits for two reasons:

1. Avoid the methane release in the environment due to decomposition of biodegradable waste materials
2. Saving equivalent quantities of fossil fuels by effectively using liberated biogas

An organized Nisargruna industry can make these carbon credits possible thereby adding valuable foreign exchange to our reserves. Moreover we will be happy that we have played our role in saving the environment from release of green house gases like methane. Methane has the most damaging green house effect.

Almost one crore people are likely to be employed on these Nisargruna plants. A large number of indigenous industries will get benefited by large scale implementation of decentralized Nisargruna project. These plants will process the entire biodegradable waste of the country adding advantages in health sector. Our country bears brunt of infectious diseases mainly because solid waste management is highly poor. The general health of the country and specifically aesthetics will improve making our country clean. What we need at this juncture is political and administrative will to identify our strength and take some bold decisions to implement the bio-energy concept. Except for metro cities, we have enough land sites available to put up these projects. Even in metro cities, careful allocation of space in existing sewage treating plants, crematoria, big residential colonies etc. is possible to raise these plants.

We need energy for industrial and civil security. We need organic manure for food security. Bio-energy offers an excellent gateway for obtaining both at reasonably good price and in perfectly eco-friendly manner.

LIST OF VISITORS NISARGRUNA PLANT, MATHERAN

Name	Designation	Date
Dr. Anil Kakodkar	Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy	
Dr. Goel	Secretary, Ministry of Environment, Maharashtra State	
Dr. K. B. Sainis	Director, Biomedical Group, BARC	
Shri A. S. Chavan	Head, Civil Engineering Division, BARC	
Dr. A. R. Shukla	Director, Biogas, Ministry of New and Renewable Energy, Delhi	
Dr. Nipun Vinayak	District Collector, Alibag District	
Dr. Devki	Health Commissioner, Bangalore MC	
Shri Bhat V. M.	Deputy Municipal Commissioner, Thane	
Dr. Sudarshan	Vice President, Wipro eco-energy	
Smt. Jyoti Ambekar	Sahyadri Channel, Mumbai Doordarshan	
Shri Daniel	CAO, TCS, Thane	
Shri Mantri Sunil	AO, TIFR, Colaba, Mumbai	
Shri Ajit Saraf	Regional Officer, MPCB, Maharashtra State	
Shri Sontakke	Regional Officer, MPCB, Maharashtra State	
Shri More	Regional Officer, MPCB, Maharashtra State	

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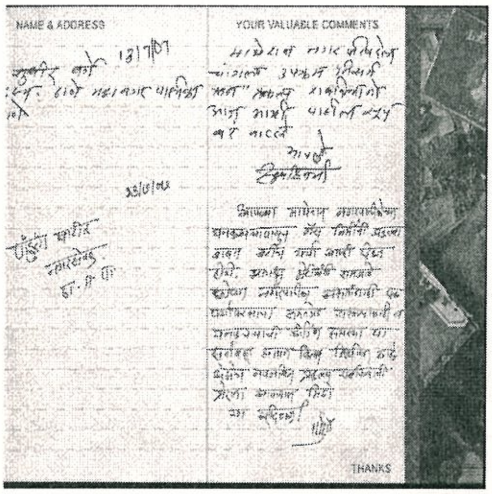
Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy

Dr. Suresh Joshi, Commissioner, Right Of Information Commission, Maharashtra State

Shri Ratnakar Gaikwad, Metropolitan Commissioner, MMRDA

Shri A. K. Jain, Principal Secretary, Water and Sanitation Department, Maharashtra State

Dr. Sreekumar Banerjee, Director, Bhabha Atomic Research Centre, Mumbai

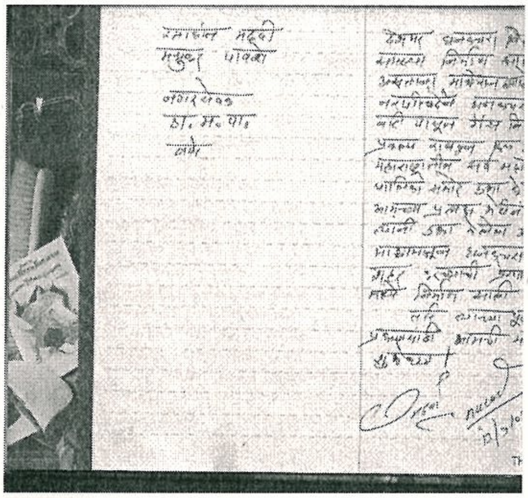


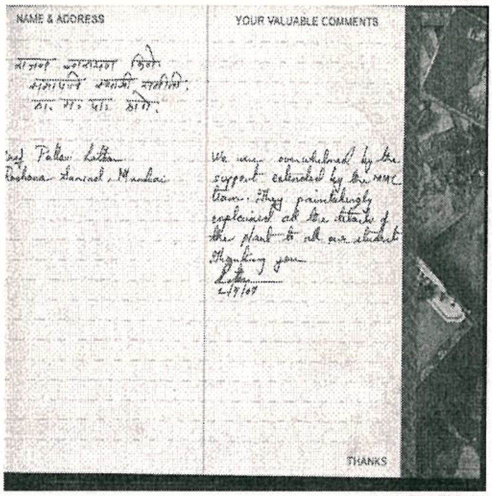
NAME & ADDRESS

YOUR VALUABLE COMMENTS

13/7/07

THANKS





NAME & ADDRESS

YOUR VALUABLE COMMENTS

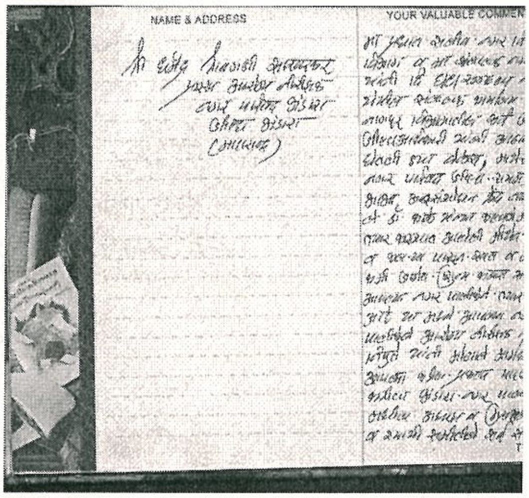
rof Pallavi Latkar
Rachana Sansad, Mumbai

We were overwhelmed by the support extended by the NMC team. They painstakingly explained all the details of the plant to all our student

Thanking you

Latkar
2/7/07

THANKS



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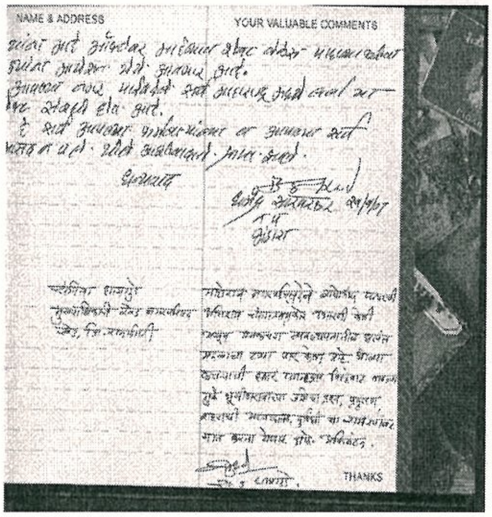

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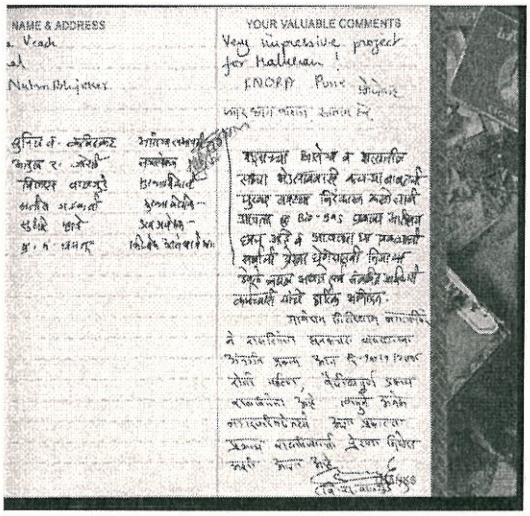

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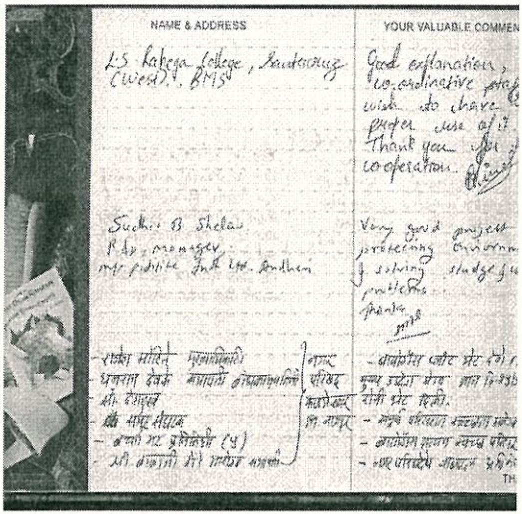
YOUR VALUABLE COMMENTS

Very impressive project for Kalyan!

ENORA Pune

THANKS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L.S. Raheja College, Santacruz (West). BMS

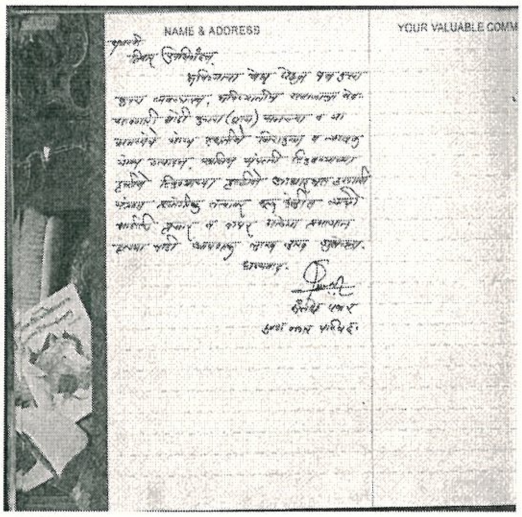
Good explanation, co-ordinative staf wish to have proper use of it. Thank you for cooperation.

Suchi B Shelar
R&D manager
[illegible] Andheri

Very good project protecting environm & solving sludge [illegible] problems. thanks

[illegible]

TH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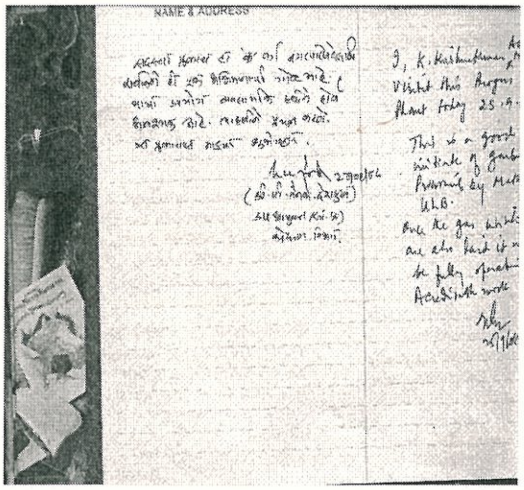

NAME & ADDRESS

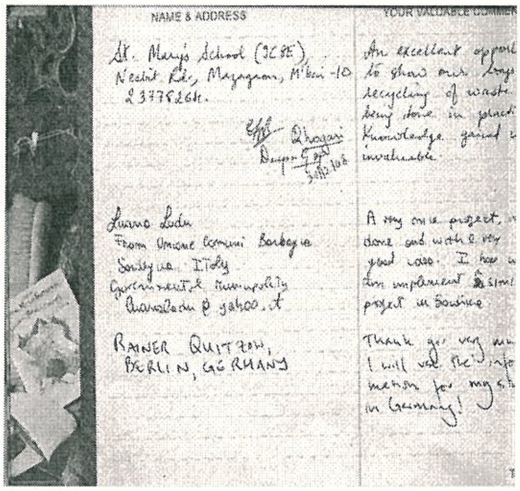
[illegible]

I, K. Krishnan, visited this Biogas plant today 25.9.

This is a good initiative of garbage processing by MCGM.

Once the gas [illegible] are also [illegible] be fully operational.

Acre[illegible] work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23778264.

Dhogari
Deepa Gopi

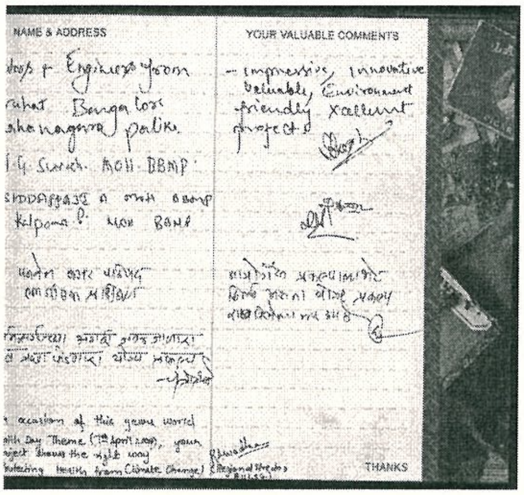
An excellent opport to show our boys recycling of waste being done in practi Knowledge gained invaluable.

Luana Ladu
From Unione Comuni Barbagia
Sorgono ITaly
Governmental municipality

A very nice project, done and with a very good [illegible]. I hope to implement a simil project in Sorgono

RAINER QUITZOW,
BERLIN, GERMANY

Thank you very mu I will use the information for my st in Germany!


NAME & ADDRESS | YOUR VALUABLE COMMENTS

[illegible] & Engineers from [illegible] Bangalore [illegible] Mahanagara palike.

- impressive, innovative valuable, Environment friendly xcellent project.

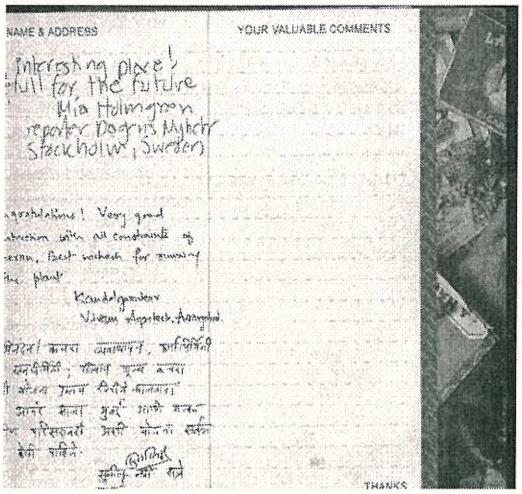
G. Suresh. MOH BBMP

SIDDAPPAJI A MOH BBMP
Kalpana P. MOH BBMP

[illegible]

On occasion of this year world Health Day Theme (7th April 2008), your project shows the right way [illegible] protecting Health from Climate Change

THANKS

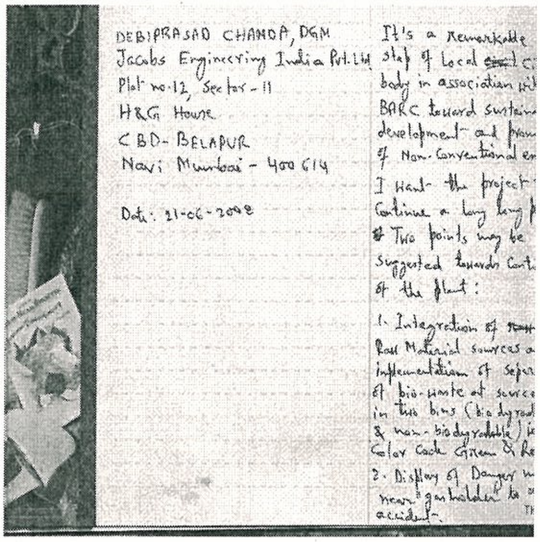

NAME & ADDRESS | YOUR VALUABLE COMMENTS

Interesting place! [illegible] full for the future
Mia Holmgren
reporter Dagens Nyheter
Stockholm, Sweden

Congratulations! Very good [illegible] with all constraints of [illegible]. Best wishes for running the plant
Kandalgaonkar
Vikram Architect, Aurangabad

[illegible]

THANKS

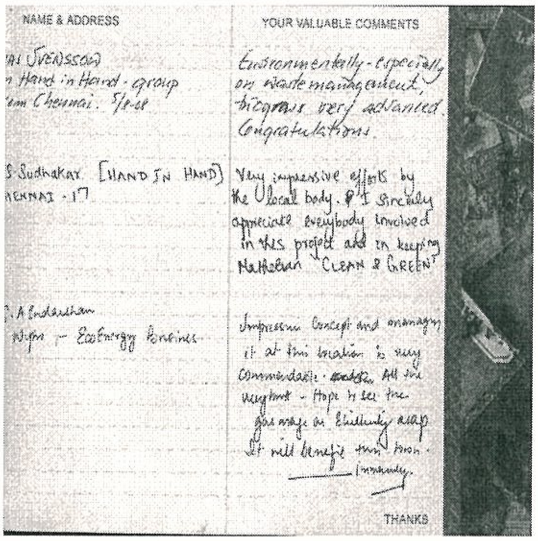


DEBIPRASAD CHANDA, DGM
Jacobs Engineering India Pvt. Ltd
Plot no. 12, Sector - 11
H&G House
CBD - BELAPUR
Navi Mumbai - 400 614

Date: 21-06-2008

It's a Remarkable
step of Local ~~[illegible]~~ ci
body in association wi
BARC toward sustain
development and prom
of Non-Conventional en
I want the project
Continue a long long p
Two points may be
Suggested towards Conti
of the plant:

1. Integration of ~~[illegible]~~
Raw Material sources a
implementation of separ
of bio-waste at source
in two bins (bio degrad
& non-biodegradable) in
Color Code Green & Re
2. Display of Danger w
near "gas holder" to a
accident.



NAME & ADDRESS

YOUR VALUABLE COMMENTS

ai Svensson
n Hand in Hand - group
am Chennai. 5/8-08

Environmentally - especially
on waste management,
biogas is very advanced.
Congratulations.

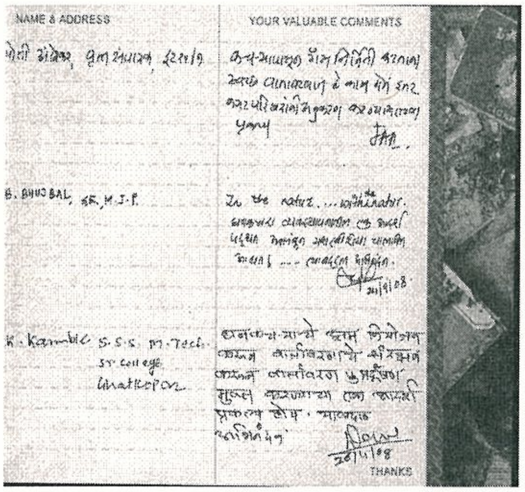
S. Sudhakar [HAND IN HAND]
HENNAI - 17

Very impressive efforts by
the local body. & I sincerely
appreciate everybody involved
in this project and in keeping
Matheran "CLEAN & GREEN"

C. A. Sudarshan
Wipro - EcoEnergy Business

Impressive Concept and managing
it at this location is very
Commendable. ~~[illegible]~~ All the
weightage - Hope to see the
gas usage on Electricity also.
It will benefit this town
immensely.

THANKS



NAME & ADDRESS

YOUR VALUABLE COMMENTS

[illegible]

[illegible]

B. BHOSAL, SE, M.J.P.

In the nature.... with the nature.
[illegible]
20/9/08

K. Kamble S.S.S. Pt. Tech.
Sr college
Ghatkopar

[illegible]
20/4/08

THANKS

Visit of Dr. Anil Kakodkar

Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy visited Nisargaruna plant at Matheran dated 23/3/2008 for MMR-Environment Improvement Society

MECHANICAL EQUIPMENTS

1. AIR COMPRESSOR

2.BIOGAS METER

3. MECHANICAL MIXER

4. MECHANICAL MIXER