Indebted to Nature
(Nisargaruna)

Wastewor(l)d Series

Indebted to Nature

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Under the guidance of Dr. Sharad Kale

Stree Mukti Sanghatana

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Introduction

The booklet series Wastewor(l)d, is an effort to disseminate our knowhow in the field of solid waste management. Since 1975 Stree Mukti Sanghatana (SMS) is working towards the empowerment of women. With the objectives to realise the ideals of equality and social justice, SMS consciously began working amongst the waste pickers in Mumbai, from 1999. SMS's Parisar Vikas programme aims to address the problems of waste picking women who are engaged in the 'menial' tasks of 'cleaning waste'. Additionally, Parisar Vikas addresses the problem of waste management engulfing our urban existence. Prima facie waste management is an environmental and health issue but poverty, equity, power, caste, gender, human behaviour, political will and good governance are also associated with waste management. Following the principles of environmental justice is the key component in our work, as we strive towards zero waste. Therefore, our emphasis is to highlight the socio cultural dimensions of environmental issues. SMS has introduced these issues in each booklet of this series.

These books discuss many aspects of solid waste management, a few solutions and good practices. Publication of this series is possible with the support from European Union.

Looking forward to your feedback!

Foreword

Nisargaruna technology is an outcome of Padmashree Dr. Sharad Kale's research. Dr. Kale is an M.Sc., Ph.D. (Microbiology) and retired as a senior scientist from Bhabha Atomic Research Centre. Nisargruna literally means Nature'sobligation or being obligate to nature. He designed the Nisargruna plant with the thought that what is taken away from nature, should be returned in useful manner. It is a fairly simple technology. The only obstacle in implementation is our mindset about dirt, disgust engulfing the word waste. This is the right time to shed away those feelings and learn about appropriate methods for the management of solid waste. The Nisargruna plant is one such method which is being successfully practiced in many cities across India. Stree Mukti Sanghatana (SMS) is one of the first organisations to acquire this technology and use it in the public domain. Several women waste picker members of SMS, in Mumbai, are trained in the use this technology.

This book is a small effort to share our knowledge acquired through practice. We hope to reach out to as many people as possible so the technology and the philosophy behind it will be spread.

- Jyoti Mhapsekar

Indebted to nature

We consider waste as an eye sore. Each and every citizen on the globe is a waste generator, but most of us are unaware that waste is 'resource in the wrong place'. We either squander or simply neglect waste.

Wet waste (compostable) constitutes a major portion (almost 50%) of the total waste generated in India. In the present situation only 35 to 40 lakh tons of fertilizer is generated from this wet waste. Our country can produce 600 lakh ton of organic fertilizer from available wet waste, provided it is segregated. For that, we have to learn proper methods to treat wet waste. One method of wet waste management is composting and the other is biomethanation, i.e. obtaining biogas- mainly Methane- from organic waste.

What is biomethanation?

Biomethanation (or Methanogenesis) is the capturing of Methane by microbes known as Methanogens. Certain micro-organisms are used for this which are identified as capable of producing Methane from biodegradable

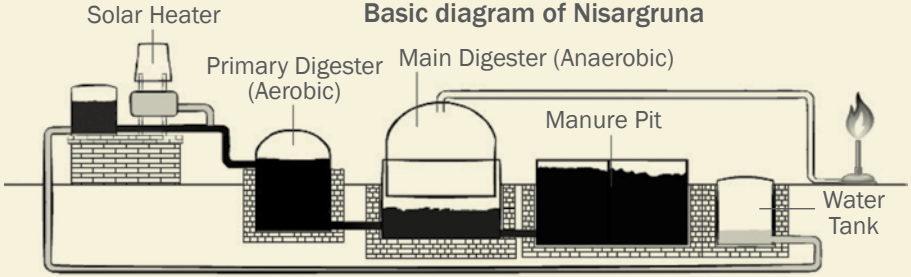
waste. Gobar gas plant is one example of biomethanation in which cow dung is used aswet waste . In the pre independence era many villages in India had anaerobic (in the absence of Oxygen)Gobar gas plants where cow dung was used as homogenous material. But the waste generated in cities today is not homogenous. Biogas plants need properly segregated and homogenized biodegradable waste. Many countries are using anaerobic technology to produce biogas and these plants are highly technical. They have to again purify gas and manure in anaerobic process. Dr. Sharad Kale, who retired as Senior scientist from Bhabha Atomic Research Centre at Mumbai (Govt. Of India), designed and developed Nisargruna, a simple aerobic(In the presence of Oxygen technology to produce biogas from urban waste. We will learn about this technology and process in this book.

What is Nisargruna ? (Indebted to Nature)

Nisargruna technology is meant for processing biodegradable waste resource materials (wet waste) originating in kitchens, markets and slaughter houses. The technology is based on the Nisargruna concept which acknowledges the

role of nature in sustaining life and also reminds us to play our role in handling resources sustainably so future generations can enjoy the same quality life. This process involves aerobic and anaerobic phases which ensures complete degradation of bio-waste. The volume reduction is about 90%. There are two useful byproducts viz. Nisargjyoti (biogas) and organic manure generated in this degradation process. Nisargjyoti-Nature's light (biogas) which is rich in Methane can be used for cooking or thermal applications while organic manure can be used for fortifying soil fertility.

Basic diagram of Nisargruna



100 kg Plant at TISS

Dome - Main digester

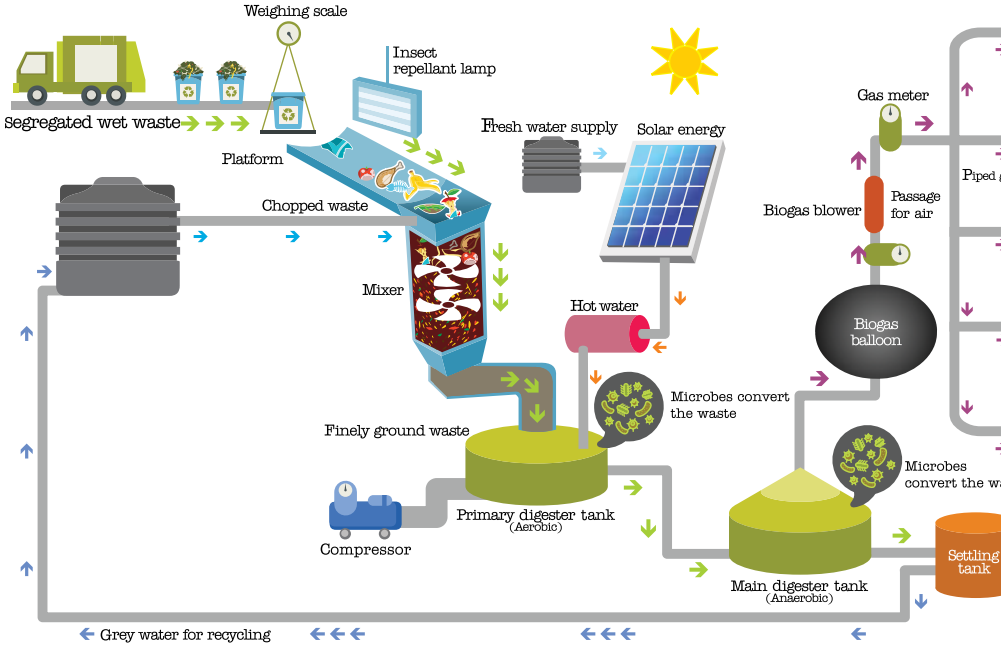
This Improved design of Biogas plant saves space as primary digester can be constructed underneath the processing room. Only the dome of main digester can be seen.
The processing room is used for fine sorting of waste, grinding and mixing.

The capacity of this plant is to process 100 kg wet waste per day.

The plant includes following structures -

A platform (for intake and segregation of waste), Primary Digester (aerobic), Main Digester (anaerobic), Water removal chambers, Manure pits, Recycle Water-tank, Solar Panels, Chambers and Pipe lines, Rooms (to store instruments & fertilizer) Covered space to cure fertilizer, Toilet for staff. The machines and instruments used in the plant are: Weighing Scale, Fly Repellent Lamp, Mixer (Grinder), Solar Heater, Air Compressor, Gas Meter, Gas Blower, Water Pump, Slurry Pump, Generator, Magnet (for separation of Iron from waste), Chopper, Litmus Papers, Buckets, Sievers, Bags.

Processing Room - fine sorting


Weighing scale
Insect repellant lamp
Segregated wet waste
Platform
Fresh water supply
Solar energy
Gas meter
Chopped waste
Biogas blower
Passage for air
Mixer
Hot water
Biogas balloon
Microbes convert the waste
Finely ground waste
Microbes convert the wa
Primary digester tank
(Aerobic)
Compressor
Settling tank
Main digester tank
(Anaerobic)
Grey water for recycling

Domestic kitchen fuel

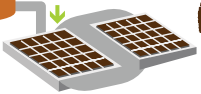
Vehicular fuel

Boiler fuel

Fuel in hotels

Electricity generation

Remainder sludge



Organic manure

Flows

- wet waste
- biogas
- grey water
- recycled water
- fresh water
- hot water

1 Tonne Plant

Nisargaruna

80 Cubic meters gas + **60** Kg. of organic manure

OR

120 Units of electricity + **60** Kg. of organic manure

Preparation to make the plant functional

After construction the plant needs to be prepared for the actual process. This first charge should be done only once, at the beginning. First the main digester is filled with cow dung to 80% capacity. Then equal amount of water is added. 20% of this mixture is then poured into the primary digester and transferred 80% into the main digester. The primary digester contains aerobic but the main digester must remain air tight (unaerobic). This allows the growth of different types of bacteria which we call 'culture'. This process takes 10 days in summer and 20 to 25 in winter. The biogas released in the process has to be vented out. (It is advisable not to use this gas as it may not be suitable for combustion). Now the plant becomes ready to process wet waste. It is functional as long as it is fed with waste and maintained properly.

Process

The three steps of biogas production are as follows; 1) Hydrolysis 2) Acidification and 3) Methanogenesis. Various bacteria are involved in these processes.

Hydrolysis –

The organically rich bio-degradable portion of solid waste is mixed with recycled water to form a slurry. The water volume should be exactly of the weight of biomass i.e. if 100 Kg waste is being fed, we must add 100 Lts of water.

Acidification

Acid-producing bacteria are involved in the second step. These are strictly aerobic. An air compressor maintains aerobic conditions in the predigester.

The slurry is then aerobically digested in predigester, where organic matter is converted to organic acids. The pre digestion is accentuated by the addition of hot water and intermittent aeration. Hot water obtained using solar energy is added to raise the temperature to 50°C. If sunlight is not sufficient especially during winter, provision can be made to use part of the biogas generated to heat the required quantity of hot water using Methane stoves. The mixture here should be mild to fairly acidic. And the acidic nature has to be measured

with the help of a litmus paper. If the mixture is found to be alkaline, cow dung must be added to increase the acidic nature.

Methanogenesis

From the pre-digester, the slurry enters the main digester. For the first time, the process of methanogenesis takes place for about 15 days in this digester. This digester is sealed and is without air and light, therefore an anaerobic condition is created for bacteria to work efficiently and successfully. Here the mixture needs to be slightly acidic. Methane is released from the cellulosic materials in the slurry. The undigested materials are then passed on to the settling digester. The gas is captured in the dome. To extend the capacity, a balloon can be attached to the dome. Additional gas can be captured in the balloon. Undigested matter flows as a slurry to the slurry pit which is a good fertilizer.

Thermophilic microbes kill the harmful, toxic bacteria and Methane (purity up to 65%) is produced. Since the waste resource is processed at higher temperature, weed seeds are killed completely and the manure becomes weed free.

After about a month, high quality manure can be dug out from the settling tank. There is no odour in the manure and the organic content is high, which can improve the quality of humus in soil. The fertilizer is almost neutral acidic.

The gas can be used for many purposes such as fuel for vehicles, in commercial as well as domestic kitchens. Electricity can also be generated from this gas, if needed.

Products obtained from 1 ton of waste

Organic waste type	Biogas released	Fertilizer obtained
Uncooked food e.g. decaying vegetables & fruits,	20 to 25 Kg	80 to 100 Kg.
Cooked, soiled food	40 to 50 Kg	40 to 50 Kg
Mixture of above	30 to 40 Kg.	70 to 80 Kg

About waste input to the process

In the Nisargaruna process the gas and fertilizer produced depends upon the type of waste used. If, for example only green leaves, twigs or branches

of trees are used, a large quantity of lignin is produced, decomposing which will take a different process. If the quantity of vegetation like vegetables dry leaves, twigs and branches etc. is more, more fertilizer and less biogas is produced. If the quantity of cooked, soiled or decayed food is more, then more biogas and less fertilizer is produced.

About 85 % – 90 % of the waste is decomposable in the process. Of this, about 80% waste is either cooked food, vegetables or green vegetables which need not be cut further. This waste can be separated by hand or a mixer of less power can be used. This type of waste is usually generated in vegetable market households and hotels. 10% – 15 % of the waste that cannot be decomposed need to sorted by hand. The waste produced by vegetable and meat markets, food processing units is usually mixed with plastic, jute sacks etc. Hard bio-wastes like jack fruit skins, bagasse, coconut shells, big bones, horns etc. needs to be cut with heavier machines.

Usable wastes for Nisargaruna

- Cooked soiled or rotting vegetables and fruits generated by hotels.

- Fruit and vegetable peels, stems, roots and leaves
- Small waste paper pieces
- Animal innards from slaughter house (abattoir)
- Dung
- Moss, algae, growth in ponds and lakes etc.
- Dry leaves
- Wet waste devoid of plastic, produced in fairs, ceremonies, festivals etc.
- Processed food waste
- Waste produced in fish, meat, chicken and mutton market.

Waste not usable in Nisargaruna

- Coconut shells and egg shells
- Feathers and hair
- Green twigs, wood and big bones
- Though it is possible to use wastes like bagasse branches and twigs etc,

itt it requires excessive chopping.

Water consumption

A one ton processing unit can process a thousand kilogram of waste and requires 1000 liters of water. One hundred litre of hot water (heated by solar or otherwise) needs to be used in the primary digestion digester. This quantity can be increased up to 500 litres however the total amount of water used should not need 1100 litres.

Recycling of water

60% of the water separated from fertilizer (scum) can be reused in the primary digester provided it can be diverted back to the primary digester from the main digester. Solar panels require fresh water to prevent the panels from rusting.

Biogas Usage:

- Best used in households, hotels and boilers

- Specially designed stoves are required for biogas usage
- Anyone who owns this stove can be provided with this gas if they live near the production plant otherwise the cost of piping gas has to be factored. This gas can be provided using blowers within one-kilometer radius of the production plant.
- This can be used in crematoriums instead of electricity, provided the digestion digesters are located in the crematoriums.
- Generators can be used to produce electricity from biogas. 10-15 kilo watt generators are available which can be used. A 5-ton project can produce 500 units of electricity.
- It is possible to transport Methane by filling it in cylinders.
- Can be used in vehicles instead of diesel or petrol. Many European countries use this which requires a 25 -50 ton process. So this unit needs to be near a huge market where bio-waste is generated. This can save on importing diesel.
- Re-fertilizing the land using the fertilizer produced: Organic fertilizer is a boon to nature – not only it is weed free it also has high quantity of

nitrogen, phosphorus, potassium and Iron.

Technically Nisargaruna is an easy process to run. With proper training even an illiterate or semi literate person can run this plant.

Training includes

- proper segregation of waste
- testing the pH factor by litmus paper
- measuring the right quantity of waste and water proportion
- drying the fertilizer produced

Nisargruna management

Local organizations start this project with a lot of enthusiasm but unable to sustain it. Finance and human resources are sometimes notprovided in the timely manner. So we need to look at following factors before starting a Nisargaruna project.

The main objective of Nisargaruna is to manage the waste generated in the

urban areas. Biogas and fertilizers are the byproduct of this process. If waste is not properly segregated, or mixed waste is used, the project will become a dumping ground and the stench will be unbearable.

The place where the waste is generated and the mode of transporting this waste must be clearly mentioned in the contract.between owner and the contractor. If the waste is not segregated at the very source, provisions have to be made to decide on who will be penalized and how. The extra time of the worker spent in segregating such waste leads to inefficiencies.

Likewise clauses need to be provided for handling mismanagement by the processing/managing staff.

The time when the waste will be delivered is equally important especially for a large project. If the waste comes in too early or too late it may rot before the process is started. As it takes two to three hours for sorting the wastein the unit, it is better if it is brought in multiple times during the day for the process to run smoothly. At least 75% of the waste need to be sorted properly for the bacteria to work effectively. As cleanliness of the premises, drying

the fertilizer, weighing it and packing it are also the parts of the project, it is imperative that the segregated waste is brought in the right time.

In order to sort the waste, a long platform or table (preferably with stainless steel top) near the mixer (grinder) is necessary. Cleanliness and removal of unwanted waste from the premises are also important. A person has to be identified for this job. The waste that cannot be used, recycled or sold needs to be handled properly. A person needs to be appointed for disposing of such waste on specific days so that it does not get accumulated and make the premises unclean. Segregated bio-waste from hotels and market places, needs to be picked up separately. The timing of the waste delivery and of the workers has to match. If the waste remains for too long it tends to rot and create a stench. Waste must be treated within two hours of delivery. If treated in proper time, the process is more effective.

People responsible for the delivery of this waste need to be trained to keepthe premises clean.

The sorting table attracts a lot of flies and pests so repellents are needed.

These kind expenses have to be included in the project. providing safety gears, disinfectants, pesticides ,soaps, aprons etc. must be made mandatory for the plant operators.

The process to increase the capacity of the project requires waste to be included in small quantities. When we eat too much our stomach gets upset, similarly adding the waste in large quantities in the beginning can upset the bacterial process. Hence waste addition should be incremental.

Quality of fertilizer

The fertilizer/compost produced in nisargaruna project contains high quantity of carbon. This carbonized fertilizer increases the effectiveness of the microorganisms present. The difference between the vitamin pills and wheat porridge is the same as that of artificial and organic fertilizers. The nitrogen, phosphorous and potassium content of organic fertilizer is not important. The important parameter for organic fertilizers is the carbon content. However, it needs to be mentioned that the nitrogen, potassium and phosphorus content of organic fertilizer is not negligible. Usually 1 – 3% nitrogen and 0 - 1 % of

each phosphorus and potassium can be present in the organic fertilizers.

FAQ -

Why is hot water used?

Water helps us to grind the mixture and make it uniform, which makes it easier for the bacteria to work effectively. The Bacillus bacteria present in pre digester works best in hot water and pure oxygen. Once the temperature rises to 45-500 C, the bacteria starts working and produces high quality fertilizer.

How long can the mixture be kept in the digesters?

The mixture can be kept in the digester for 48-72 hours (2-3 days)

Why the digesters (tanks) are on different levels? (The first digester on higher level than the second)

The digesters are on different levels and on a slope to help shift the mixture from one digester to another smoothly. As the first digester fills up, due to the slope and earth's gravity, the mixture naturally moves from the pre digester

to the main digester. No energy is required to transfer the mixture from predigester to the main digester.

Why is the main digester covered?

Unlike in the pre digester, this digester has Methanococcus bacteria which work at their best in absence of light and air. To enable them to process, the mixture in this main digester, it is completely sealed. Methane or biogas is produced in this digester.

How will we know when the gas is ready for use?

The dome on the main digester is fitted like a cap. Once gas is produced this dome rises up and floats on the water. The ready gas can now be sent via pipes for use. Once the gas is completely consumed, the dome falls back in the digester.

What happens to the wasteslurry produced in this digester (Main digester)?

Waste produced here is actually a boon to us. It's sent to a sand pit where, the fertilizer floats on the top and water remains at the bottom. This fertilizer

is removed from the digester and dried so that it can be used. The water is not wasted either. It is sent through pipes to the pre digester and is reused for running the mixer.

Remember. The sequence of the waste should be maintained and should never be confused. The gas can be produced by sending the waste in the pre aerobic digester with the mixer and then to the main anaerobic digester.

Why doesn't the first digester produce fertilizer?

The bacteria in the pre digester can grow well and digest the slurry. The role of these bacteria is to destroy Sulphur produced in the slurry. This enables bacteria in the main digester to work effectively and generate high quality gas from the uniform Sulphur free mixture. Fertilizer is a by product of this process and is produced at the end of the process i.e. in the main digester.

What is the purity of the gas?

Biogas produced in Nisargruna plant contains 70-75% Methane, 10-12% carbon dioxide and 5-10% steam. A steam trap is used to collect all the steam

that's produced. Hydrogen sulphide produced in this process gets released as sulphur dioxide. So the gas produced by this process is very pure and does not need to be purified. The "natural flame" produced by this gas is bright blue in colour.

Is biogas used abroad? Is it better than what we produce?

Abroad, especially in the European countries, units produce biogas from urban waste. However, they use only one digester where the anaerobic process is used, so the Methane gas produced is only 50-66% pure. Also the quantity of carbon dioxide and hydrogen sulphide is high so this gas and the fertilizer produced has to be purified. So comparatively, the process used in Nisargaruna is environment friendly, less expensive and easy to use.

How to maintain record of the procedure

No.	Date	Vehicle No.	Waste In (Kg) (Wet waste)	Ready to Feed waste (Kg) meticulously sorted waste	Recyclable Waste (Kg)	Rejected waste (Kg)	Gas generated	Used/Utilised for

Maintain the attendance register, comments register separately.

Nutrients in compost

1	Calcium	0.39-0.65
2	Iron	0.18-0.32
3	Magnesium	0.032-0.01
4	Manganese	0.0059 – 0.008
5	Nitrogen	2.6 -3.5
6	Phosphorous	0.8 -0.9
7	Zinc	0.007 -0.009
8	Potassium	0.8 – 0.95

Nisargruna at a glance

Waste/day	Gas generation		Compost	Area	Approx.cost in INR		Electricity
Kg/Ton	cm/ day	equivalent to LPG /day	Ton/day	M2	WO generator	With Generator	KW/day
100 Kg	6	3	0.008 to 0.01	20	7lakhs	NA	Na
500 Kg	30	15	0.04 to 0.05	50	14lakhs	17lakhs	50
1MT	60	30	0.08 to 0.1	100	20 lakhs	26 lakhs	100
2 MT	120	60	0.16 to 0.2	200	30 lakhs	40 lakhs	200
5 MT	300	150	0.4 to 0.5	500	70 lakhs	80 lakhs	500
10 MT	600	300	0.8	1000	1.5 crores	1.75 crores	1000

CREDITS

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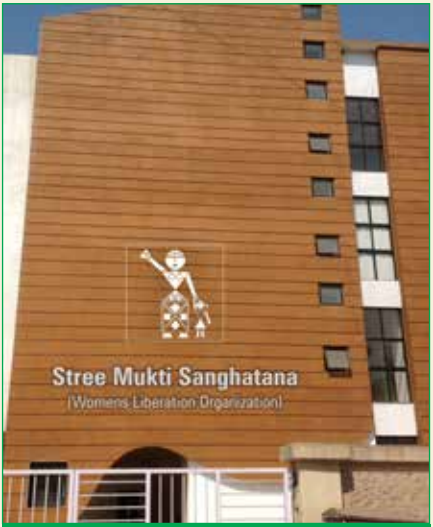

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