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Programme: M.Sc., Environmental Science

Course Title: Solid and Hazardous waste management

Course Code : CC07

Unit-V

Hazardous waste Management

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Case study

- Karlsruhe, Germany, is recognized for its effective and sustainable municipal solid waste management system, which prioritizes environmental protection and public health.
- The city employs a well-structured approach that includes waste separation, recycling, and a "pay-as-you-throw" system.
- This strategy has significantly reduced waste generation and improved resource efficiency.
- Key aspects include public education, strict regulations, and advanced technologies for waste processing.
- The success of Karlsruhe's model offers valuable insights for cities globally, particularly in integrating community participation and long-term planning to achieve sustainable waste management.

- Effective management of municipal waste is required, but local authorities in many countries are constrained by limited finances and inadequate services (Omran and Read, 2008; van Beukering et al., 1999, Omran and Gavrilescu, 2008).
- The decisions in the area of municipal solid waste management are not only very capital intensive, but also difficult from the environmental and social points of view.
- There is a need to develop, master and implement a simple, but reliable tool that will help the decision makers in the analysis process (Omran and Read, 2008; Schiopu et al., 2007).
- Local governments are usually authorized to have responsibility for providing solid waste management services, and most local government laws give them exclusive ownership over waste once it has been placed outside a home or establishment for collection .

Introduction

- As urbanization continues to advance, the management of solid waste is becoming a major public health and environmental concern in urban areas of many developing countries.
- Large municipalities and metropolitan regions are encouraged to undertake city-wide strategic planning to design and implement integrated solid waste systems that are responsive to dynamic demographic and industrial growth.
- Strategic planning needs to start with the formulation of long-term goals based on the local urban needs, followed by a medium- and short-term action plan to meet the goals (http://web.worldbank.org/).

- Karlsruhe, the former capital of the German state Baden, is a city in the South-West of Germany near the French border. The city has more than 300000 inhabitants. Karlsruhe is the location of the two highest Federal German courts .Furthermore, Karlsruhe is the residence of the district administrator, the government presidency of Northern Baden. The eldest technological university of Germany is located in Karlsruhe .

Waste Management in Karlsruhe: Stakeholders

- Different public and private sectors are involved into the solid waste management in Karlsruhe who share the responsibility for waste disposal, transportation and recycling.
- The office for waste management Karlsruhe is responsible for waste disposal, street cleaning and the municipal haulage park. Merely in some outskirts, a private disposer has been put in charge of the waste disposal. After the pickup and transportation of the different waste types, which is performed by the municipal office for waste management, the different waste types are separated and treated/ recycled by different public and private enterprises .

Segregation of wastes:

- Segregation of solid wastes is the process of separating waste materials at their source into different categories based on their composition, recyclability, or disposal methods. It is a critical component of effective waste management, aiming to reduce environmental impact, enhance recycling efficiency, and minimize landfill dependency.
- **Residual waste bins**: Old clothes (not wearable), empty folders, ash, baking paper, lead glass, broken eyeglasses, carbon bands , sanitary napkin, slides, floppy disks, vapor exhaust filter, bicycle saddle, furs, spyglasses, films , fireproof glass, lighters out of use, desiccated markers, photos, empty pens, doormats, hosepipe, coated gift wrap paper, dishes, light bulbs, plaster figures, rubber materials, gloves etc.,

- **Recyclable waste bins:** Used paper, aluminium, antennas, baking dishes, plate, lead, sinkers, blister packages, boilers, shelves, envelopes, brochures, books, electric irons, CDs*, tins, buckets, disposable plates, electric cables, foils, hair blower, cameras, gift wrap papers, beverage cans**, packages with the green dot, domestic foils, wood (small parts), yoghurt cup (empty), yoghurt cup lids, canister, paper board cotainers etc.,
- **Bio waste:** Balcony plants, banana peels, biolitter bags from paper, flower, soil, bread, egg shells, finger nails, residues from vegetable peeling, hairs, jute, coffee grounds, cheese residues, bones, diseased aeriel parts, ailment residues, fruit residues, orange peels, untreated saw dust, seeds,

Importance of Waste Segregation:

- **Promotes Recycling**:
  - Segregated materials are easier to process, reducing contamination and improving the quality of recyclables.
- **Reduces Environmental Pollution**:
  - Prevents hazardous substances from mixing with general waste, protecting soil and water quality.
- **Enhances Resource Recovery**:
  - Separating waste ensures efficient recovery of valuable materials like metals and paper.
- **Minimizes Landfill Use**:
  - Diverts recyclable and compostable waste away from landfills, extending their lifespan.
- **Supports Circular Economy**:
  - Facilitates the reuse and recycling of materials, reducing reliance on raw resources.

Disposal strategy

- **Recycling centres**: Used tires, asbestos, bedsteads, boilers, electric iron, computers, couches, electrical equipment, electronics crap, windows, sheet glass, tubes (TVs), flagging, floor covering, glass (flat glass), heraclit plates, hearth, wood (larger parts), coffee machine, suitcases, bureau, corks, ice boxes, mattresses, metals (larger parts), oil filters, lawn-mowers, mirror glass, floor-lamps, hi-fi system, chairs, tables, toasters, doors, washbasins,washing machine, breezeblocks, bricks
- **Noxious waste counters**: Paint remover, drain pipe cleaner, accumulators, used oil , oven cleaner, batteries, mordant, chemicals, disinfectants, fertilizers, energy saving lamps, defroster, softening agent, rust removers, developer, colors, photochemicals, oil for deep-frying, antifreezer, glass cleaner, grill cleaner, herbicides, wood preservative, impregnating, insectizides, lime remover, adhesives, cosmetics, varnish, bases, phosphor tubes, dissolvers, drugs, furniture polish, carpet moths preservatives, nitro diluter, oils, oil tanks, oil binders, agents, pipe cleaner, rust converter, sanitary cleaner, cooking fat residues, spirit, turpentine diluter, thermometer, weed killer, benzene, toilet cleaner tablets

Waste Disposal (pick up)

The waste disposal (waste pick up) is implemented by the office for waste management. After the waste pick up, implemented by the office for waste management Karlsruhe as municipal service provider, the different waste types are transported to different destinations.

Waste Transport : The biowaste is carried to a municipal fermentation plant, operated by Karlsruhe for composting. Recycable waste is loaded on conventional garbage trucks and delivered to the sorting plant Karlsruhe Rheinhafen Alba, a private waste disposer (Rapp, 2008).

The transport of the residual waste, which is carried to the waste heating plant (garbage incineration plant) in Mannheim (MVV), is implemented by means of an interchangeable container system: the residual waste stays in the same container from the waste collection until the delivery to the waste heating plant.

- At the container terminal of the railroad in Karlsruhe the containers are entrained from the group age vehicles to rail wagons for the haulage to Mannheim. A portal crane in the waste heating plant discharges the containers to a shuttle vehicle which carries the containers for offloading to the waste bunker.
- After emptying, the containers are returned by railway to Karlsruhe, are put on the car frames and the pick up process starts again (Rapp, 2008).
- **Waste Separation and Recycling :** The biowaste is processed into compost and screen residues in the municipal fermentation plant. A part of the compost is placed at the disposal of Karlsruhe's residents free of charge as manure for the garden, another part is used for the production of premium soil, once another part is used in agriculture.

- The screen residues are partially usable for composting, partially they can be used for energy production by incineration (Rapp, 2008). The recyclable waste which is carried to the private waste sorting plant Alba, a partner of the office of waste management Karlsruhe, is applying different kinds of segregation technologies for different recyclates.
- There is a handy separation for some materials, e.g. for wood, and there are different kinds of separation techniques by machines for the different sorts of reusable materials.
- There are, for example, screening segregations for the separation of mineral materials on the one hand and small parts on the other hand (coarse fractioning and fine fractioning). Metals are separated by a magnet separators whereas non-ferrous metals as, for example, Aluminium, are separated by an eddy-current separator.

- There are different machines applied for the separation of different sorts of paper and plastic waste, which are able to identify the tetra packages among the paper and plastic waste by means of a spectrometer. This high-tech system which is applied since about four years at Alba works as follows: The waste parts run on an assembly line and pass below a camera which is able to detect the tetra packages by a spectrometer (graphic scanning system).
- At the end, the tetra packages are blown out by an air pressure jet (Rapp, 2008). Once the waste separation of the recyclable waste is finished, the waste is pressed in large bales, loaded on trucks and transported to different private recycling enterprises.
- The paper waste is delivered to paper mills, the plastics to plastic processing factories, the metal to metal recycling plants, the wood to wood recycling enterprises and the biomass is delivered to the public energy provider EnBW (Rapp, 2008). The treatment of the residual waste is done in the private-public heating plant in Mannheim (MVV), an energy producing plant, which is partially producing energy by the incineration of residual waste .

Conclusion

- Management of domestic and bulky waste is largely assured. More serious problems arise in the management of commercial wastes; these will persist for some time. To ease the situation, greater efforts need to be made to segregate wastes at source, to sort them, and in particular, to complete, expand and newly establish treatment and recovery facilities. Until such facilities are completed, wastes will need to be sought abroad. One thing, however, is certain: There is no turning back.

NISARGRUNA (BIOMETHANATION PLANT)

Founder

- **Sharad P Kale** is a scientist known for developing a biogas plant based on biodegradable waste resource (Nisargruna). He is the head of Technology Transfer and Collaboration at Bhabha Atomic Research Centre (BARC). On 26 January 2013, the Government of India honoured him with the Padma Shri Award in the Discipline of Science and Engineering.

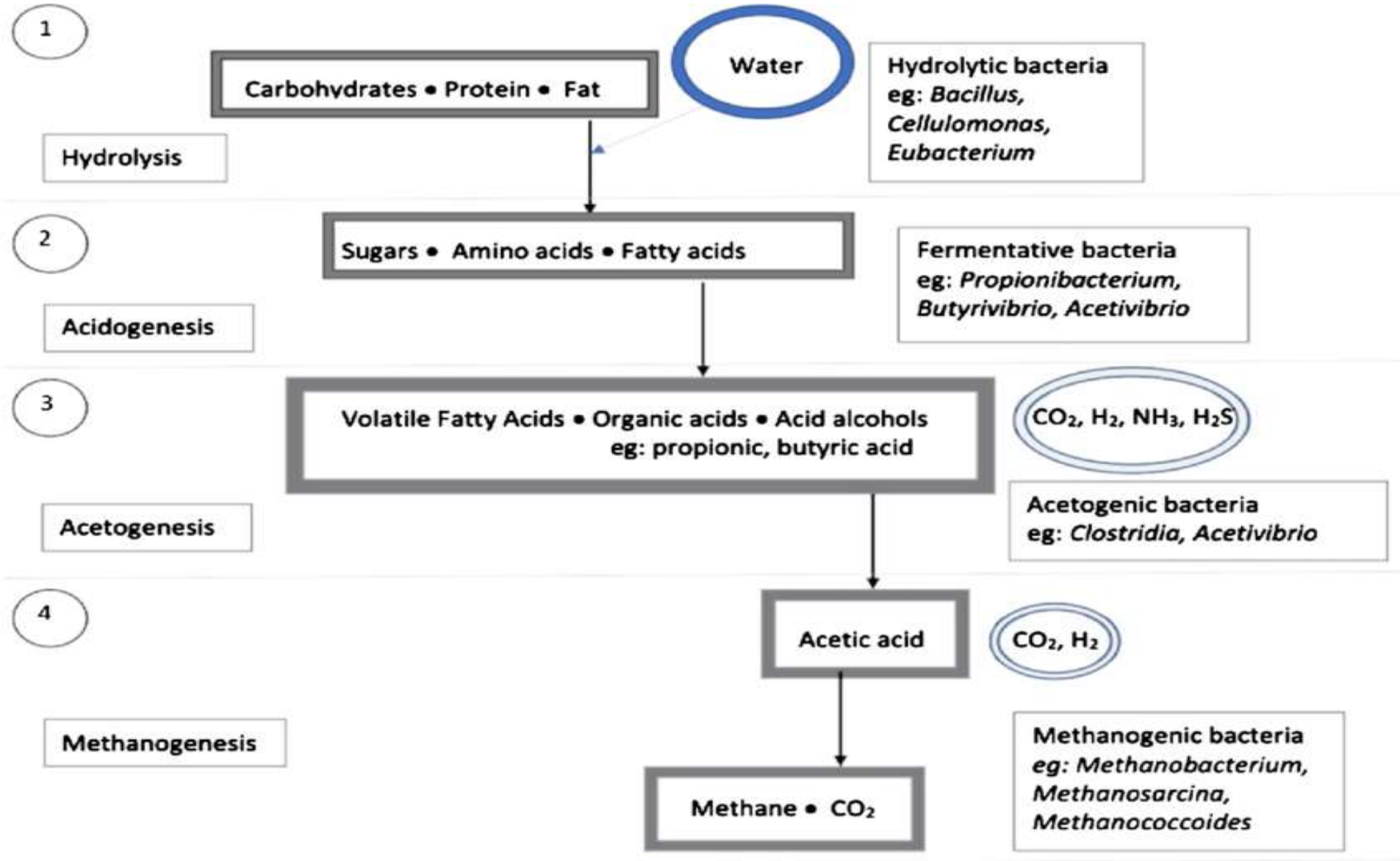
Solid waste?

- Waste disposal is one of the major problems being faced by all nations across the world. City like Mumbai generates 7000-10,000 tones waste per day and proper disposal is essential to prevent pollution and maintain esthetics.
- Out of this waste, glass, metals, some plastic and paper can be recycled. The biodegradable waste should be processed properly to maintain natural balance of essential elements in the environment.
- Disposal of biodegradable waste resource can be achieved by several means like incineration, landfills, dumping in the dumping yards, composting etc. These methods have their own hazards. Incineration can lead to respiratory illnesses. Moreover, it may lead to disruption of biogeochemical cycles of several elements and will have long term effects on biosphere.
- Vermiculture has been used in recent past in urban area, however, it has limitations of space. One of the economic ways would be to install community based biogas plants for processing.

Biomethanation?

- Biomethanation is a process by which organic material is microbiologically converted under anaerobic conditions to biogas. Three main physiological groups of microorganisms are involved: fermenting bacteria, organic acid oxidizing bacteria, and methanogenic archaea.
- **The biomethanation process which comprises the 4 stages of:**
- It's a Biological Process, and there are 4 stages: Hydrolysis, Acidogenesis, Acetogenesis, Methanogenesis. Hydrolysis- the first step in the conversion of organic material to biogas.

Biomethanation stages



NISARGRUNA PROCESS

- The waste resources which can be processed using Nisargruna Biogas plant include biodegradable kitchen waste, paper waste, green grass, leaf litter, animal remains in abattoirs, hospital waste, green plant waste, cow dung, crop residues, sugarcane, baggase, water hyacinth, etc.
- The waste is first segregated carefully to remove non-biodegradable material and then homogenized to make a slurry. It is then processed in a sequential manner first by aerobic and then by anaerobic process. The products of the process are biogas consisting of methane, carbon dioxide and water vapor & weed free good quality manure. About 70% of Water can be recycled at the end of the process.

- Nisargruna is a biogas technology that uses bioderadable waste as an input and produces biogas as an output. The Nisargruna plant can process a variety of biodegradable wastes such as kitchen waste, grass, *gobar* (animal dung), dry leaves, animal carcasses, effluent sludge from textile manufacture, etc.
- The Nisargruna process is unique as it uses a combination of aerobic and anaerobic processes. In the first phase the biodegradable input (also called feedstock is mixed with recycled water to form a slurry. This slurry enters a pre-digester tank where it undergoes an exothermic reaction that increases its temperature. In the second phase, this mixture enters the anaerobic digestion (AD) tank where methanogenesis takes place and methane (CH_4) and carbon di oxide (CO_2) are formed.
- While traditional AD plants yield a biogas with methane content of 55–65%, the Nisargruna plant with its two-phase process yields a biogas with methane content of 70–80%. The higher concentration of methane in the biogas means that it is a higher grade fuel.

- In addition to generating biogas, which may be used as a cooking or heating fuel, the Nisargruna plant also produces a weedless organic manure slurry. This slurry has a C:N(carbon to nitrogen) ratio of 12:1 to 16:1 and is a good organic soil conditioner.
- An independent study of a 0.5 TPD (tonnes per day) capacity Nisargruna plant conducted in 2015 showed that the plant had a payback period of less than three years.
- The Technology Transfer and Collaboration Department at BARC owns the intellectual property for the Nisargruna plant and has licensed it to over 50 companies (As of September 2015) that may deploy it for their customers.

INFRASTRUCTURE REQUIRED

- The following infrastructures is required for set-up a 1 tonne/day capacity Bio gas plant:-
- 1 Space : ~ 100 m2
- 2 Manpower : Two unskilled persons
- 3 Power supply : 3 phase AC
- 4 Water Supply : 1.2 kL for one tonne plant/day
- 5 Cost : ~ 16 lakhs rupees for 1 tonne/day capacity plant

- **ADVANTAGES**

Nisargruna Bio Gas Plant would serve many purposes such as:-

1 Environment friendly disposal of waste, which is the need of the hour.

2 Generation of fairly good amount of fuel biogas, which will definitely support the dwindling energy resources. The gas can be used for as fuel in the kitchen or for power generation.

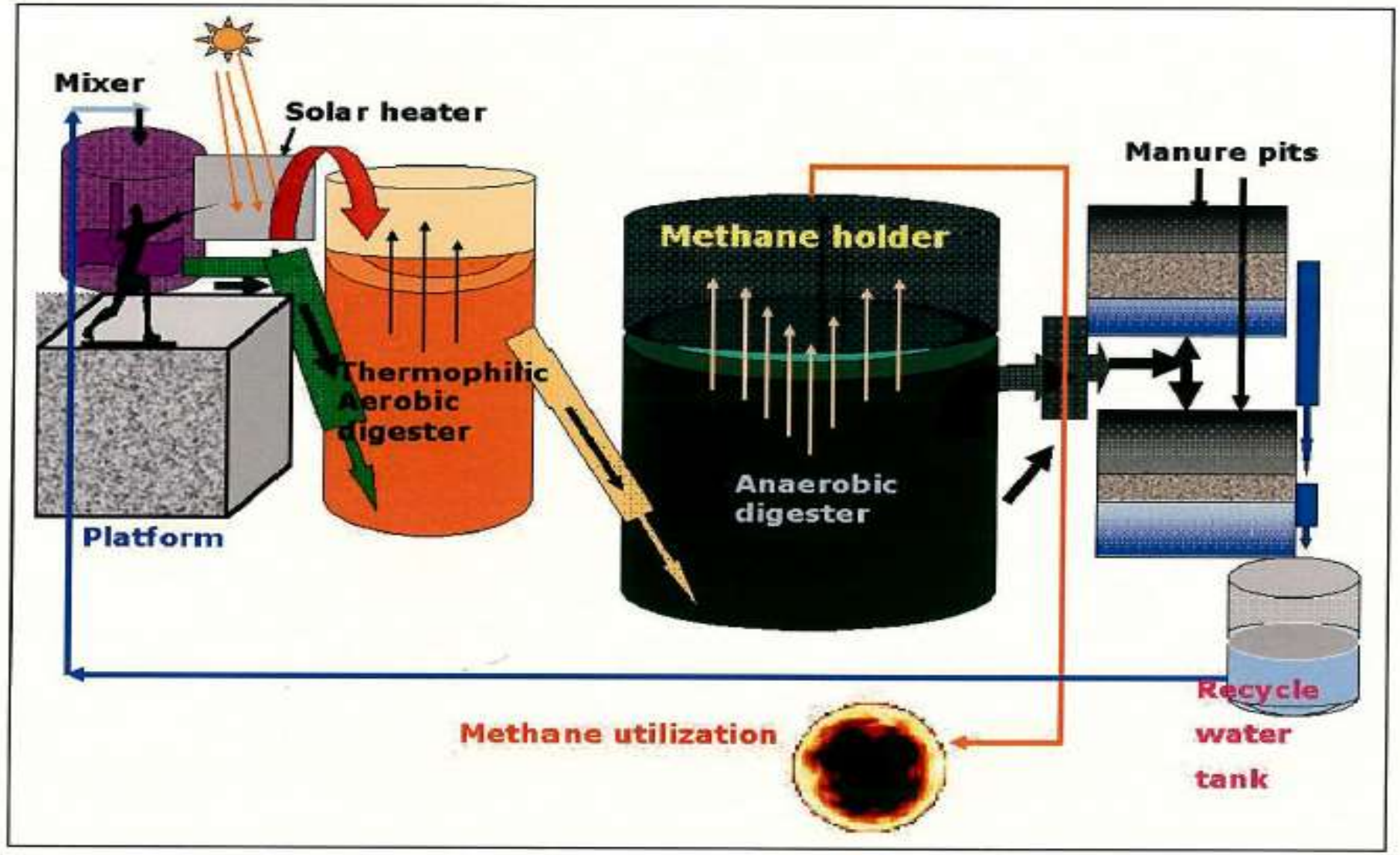
3 Generation of high quality, weed free manure, which is an excellent soil conditioner. This is very important for replenishing organic carbon in the undernourished soil after years of agriculture.

4 It offers "**Zero garbage and Zero effluent**" and provides high quality manure and methane gas. Weed free manure obtained from such waste has high nitrogen contents and acts as an excellent soil conditioner.

5 This plant could be set up for ecofriendly disposal of wet-waste generated in kitchens/canteens of big Hospitals/Hotels/Factories/residential complexes and can avoid health hazards due to dump sites. This technology of biphasic biomethanation has high potential of solving the solid waste management problems of the urban areas and provides organic manure and bio-gas as a fuel.

- **APPLICATIONS**

The Bio gas plants are useful for Municipal Corporations, Hospitals, Hotels, Housing Societies, Govt. Establishments, Abattoirs, Nagar Palika, Grampanchayat, Farmers. At present, 160 Nisargruna plants are functional in the country.


Mixer
Solar heater
Manure pits
Methane holder
Thermophilic
Aerobic
digester
Anaerobic
digester
Platform
Recycle
water
tank
Methane utilization

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

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