Sub Theme- III

Waste to Wealth
3.1. Background

Waste is a natural by-product of the phenomena of life and growth of societies. It is viewed as unwanted or unusable material that has been disposed or discarded after primary use. Plants shed leaves, animals excrete. Humans in their day to day life create a boundless heap of waste of countless variety.

Industrialization is inevitable for the development of any nation. It leads to demand for a variety of goods for improving habitat and standards of living, greater production, as well as greater consumption. This escalates production of waste in variety of forms, many of which cause serious environmental pollution and degradation. Persons with disability are prone to greater threat from mishandling of waste. In the absence of proper mechanisms for disposal and management, waste is often viewed as a menace. It not just spoils the aesthetics of living spaces, but becomes a source of pollution and poses a major hazard to health and life of all organisms.

Efficient handling of waste is an important factor in the developmental progress of any nation and the health of its people. Effective management of waste is now a national priority as seen through the Swachch Bharat Mission. This seeks to sensitize every citizen, especially the young, and make them a partner in creating a clean nation.

Waste is deeply linked to lifestyle choices. Each time we decide to use the blank side of a printed paper, turn off lights and fans on leaving a room, use water judiciously, take on our plate only as much food as we can eat, decide not to use a plastic bag, we contribute to reduction of waste or resources. In fact, since times immemorial, all societies and cultures have looked for effective management of waste and often, to put it to good use. Used and discarded materials are transformed to beautiful artifacts. Leftovers from food commonly form the
base for fresh dishes. The patched quilt is generally found across cultures. Generation of less waste, reuse of consumables, recycling of waste and recovery of valuable resources from waste are considered as good practices. They help conserve valuable natural resources and energy and also lower environmental damage caused by socio-economic development. Thus waste management is strongly linked with the idea of sustainable development.

Meeting the goals of sustainable development is an outstanding global challenge. So is waste management. Finding innovative solutions for effective management of waste is difficult as breakdown of waste requires special processes that entail time, energy, and expense. The new thinking is to address the problem at the grassroots starting at the very origin of waste generation. It is now recognized that we cannot afford to lose it as mere 'waste'. Instead, it is important to view ‘waste’ as a valuable ‘resource’ that can be converted into a variety of useful products. This process of conversion of waste to a product that can be put to primary use can be viewed as a process of generating wealth. Hence the phrase ‘Waste to Wealth’.

Waste management that leads to generation of substances and products that can be put to primary use is an emerging major sector for employment to meet the livelihood needs of the vast majority of India’s rapidly growing population. Given the magnitude of waste generated, innovative waste conversion processes can create micro-entrepreneurship opportunities on a massive scale. In India, the potential of waste to wealth enterprise is very high. Currently not enough has been done. Increasing opportunities for this enterprise can have manifold advantages. It can bring back useless, discarded waste products into economic use and lead to

1. Reduction of pressure induced by waste on the environment;
2. Creation of opportunities for income and employment generation in a relatively new area thereby enhance economic activity; and
3. Impact quality of life.

3.2. Objectives

To understand
• the challenge posed by waste and its impact on environment and health;
• how day-to-day activities generate waste;
• classification of different types of waste and mechanisms for their disposal;
• concept of 5R: Refuse, Reduce, Reuse, Recycle, Recover;
• hazards posed to health and environment and safety measures to be adopted in handling waste;
• innovative processes that generate products from waste creating wealth;
• the scope of livelihood generation through entrepreneurship.
3.3. Scope of the Sub Theme

The primary focus of this sub theme is to understand the science and art of waste management and product development. It will trace the life cycle of various forms of waste, starting from its generation to diverse forms of disposal; classification as biodegradable or non bio-degradable and hazardous or non-hazardous; process for management; mechanisms for conversion to usable products, if any; impact on health, environment and socio-economic issues.

3.4. Waste: Types & Nature

Definition: Wastes are unwanted or unusable objects or materials which are discarded after primary use, or declared as worthless, defective and of no use. Municipalities require these to be disposed of by the provisions of national law.

Examples include Municipal Solid waste (MSW) which is household trash/refuse, hazardous waste, wastewater (such as sewage, which contains bodily wastes – faeces and urine – and surface runoff), radioactive waste, e-waste and others.

Hazardous waste

Hazardous waste is any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances.
3.4.1. Biodegradable (Bio-waste)

**Definition:** Biodegradable materials are composed of waste from living organisms and the actual plant, animal or other organisms when its life ends.

**Examples:** These include human and animal waste; plant products, wood, paper, food waste, leaves, grass clippings and other horticulture waste; and remains from death of living creatures such as animal carcasses.

**Hazards posed:** It is usually believed that biodegradable waste does not cause environmental damage and is harmless. However, a quick glance at our own habitat is enough to prove that it poses health if not disposed of properly. Stagnant waste emits foul smell as it decays and becomes a breeding ground for mosquitoes and other disease causing organisms. Rotting waste emits greenhouse gases such as methane, carbon dioxide and produces chemicals like ammonia. Too much of biodegradable waste in water can deplete oxygen impacting marine life. Again, too much of cattle manure can cause health concerns.

Another major problem arises when instead of being segregated and composted, biodegradable waste ends up in large garbage dumps or landfills and gets buried under mounds of non biodegradable waste, rendering it difficult for microorganisms to break it down.

**Bio-degradation or decomposition:** This is the process of changing biodegradable materials into a useful resource. A quick look at any ecological system shows widespread synergy between organisms. Waste from one living entity often helps create a healthy environment for another organism, providing nourishment and conditions conducive for its survival and growth. Decayed organic material (compost) is commonly used as manure or
fertilizer for growing plants. It improves soil structure and provides nutrients. The process of composting requires making a heap of wet organic matter known as green waste (leaves, food waste) and waiting for the materials to break down into humus after a period of weeks or months. The decomposition can be accelerated by other living organisms such as bacteria, fungi, insects, worms, etc. and abiotic elements like temperature, moisture, oxygen, ultraviolet light, etc.

**Creating sustainable wealth**

**Organic Agriculture:** With greater sensitivity to issues related to sustainable development, agro-ecological farming methods are gaining in popularity. These rely on ecological processes to sustain the health of soil as well as treating farming as an integrated, holistic, interconnected process of food production by optimizing the farm in design and closely knit nutrient and resource recycling. Instead of synthetic fertilizers and pesticides, compost, green manure and bone meal are key ingredient in organic farming and also on non-chemical modes of pest and disease control. Consciousness towards healthy lifestyle has seen organic farm production and trade emerging as an important sector in India as in other parts of the developing world. According to business chamber ASSOCHAM, current organic food market was estimated to be about Rs.3350 crore in 2016 and predicted to treble in next four years.

**Bio-fuels:** Another important direction in bid for sustainability is use of bio-fuels from biomass or bio-waste. Biogas production is a clean low carbon technology for conversion of organic waste into clean renewable biogas and a source of organic fertilizer. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matter/ wastes can be used as energy source for cooking, lighting, refrigeration, electricity generation and transport applications.

Biomass has always been an important source of energy in our country. According to the Ministry of New and Renewable Energy (MNRE), about 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country’s population depends upon it for its energy needs. MNRE is promoting development of efficient technologies for its use in various sectors of economy. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shell, soya husk, de-oiled cakes, coffee waste, jute waste, groundnut shells, saw dust etc.

Applications range from use of bio-fuel in rural/urban kitchens to grid power generation to meet varied energy demands of a sugar mill, an entire village and even a smart city. This is an industry that attracts an investment of Rs. 600 crore every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in rural areas. Maharashtra leads by example generating about 1220 MW of Biomass power.

**3.4.2. Non Biodegradable Waste**

**Definition:** Non Biodegradable waste includes materials that do not breakdown or decay naturally, that is, cannot be decomposed by microbes and abiotic elements or dissolved by natural agents or biological processes.
Examples: These include glass, metal, baked pottery, ceramics and plastic items; most forms of medical waste (Biomedical waste); electronic/electrical devices (E-waste); construction and demolition waste (C&D). Most of the inorganic waste is non biodegradable in the sense that it could take from a few weeks and years to thousands of centuries to decay. In fact, our understanding of ancient civilizations rests on archeological findings of non biodegradable artifacts of that era.

Plastics: About 15,342 tonnes of plastic waste are generated in India everyday, of which 6,137 tonnes remain uncollected and littered, 9205 tonnes are recycled. Lack of awareness and absence of effective tools to collect back the discarded plastic products including the wrapping material has led to the indiscriminate littering and disposal of plastic waste.

Biomedical Waste is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals. Common examples are diapers, sanitary pads, syringes, shaving blades, ear buds, finger nails, band aid, dressings, used cotton, dry cloth items, surgical waste, body parts, animal bones etc.

E-Waste: Electronic products nearing the end of their “useful life” are termed as “E-waste”. Examples include discarded computer monitors, motherboards, cathode ray tubes, televisions, VCRs, stereos, Printed Circuit Boards (PCB), mobile phones and chargers, CDs, headphones, Liquid Crystal Displays (LCDs)/ plasma televisions, air conditioners, refrigerators and so on. In India, computer equipment accounts for major fraction of e-waste material.

Construction and Demolition Waste: This refers to materials that are unused, damaged or unwanted during construction and the demolition debris. The list is large and includes rubble, drain silt, marble sludge, bricks, concrete, tiles, wood, nails, pipes, roofing, plaster
boards, electrical wires, insulation, etc. Site preparation can involve digging and felling of
trees. Construction waste may contain lead, asbestos, paint, etc. It is estimated that almost
10 to 15% of the materials that go into construction of a building are wasted.

**Hazards posed**
Disposal of non biodegradable waste is a major challenge. It ends up taking space, cluttering
habitat and creating land mess. Or it ends up being burnt, dumped in water bodies and
landfills. Such waste deposits cause large scale pollution of land and water posing several
environmental and health problems.

**Plastics:** Consider the commonly used plastic. The plastic boom started after the second
word war. It is ubiquitous and used in carry bags, bottles, other packaging, toys, cellphones,
refrigerators, automobiles, pipes, construction materials, microfibers, et cetera. Consumer
needs have led to newer types of plastic and polyester clothing that is more durable and
lasts even longer. By one estimate, industry has made 9.1 billion tonnes of plastic since
1950. Nearly 7 billion tonnes are no longer used. About 9% got recycled; another 12% was
incinerated. This leaves 5.5 billion tonnes of plastic waste littered on land, inside landfills
and floating on water bodies. Even when shred into smaller pieces, they last for thousand
years. Because plastic is made from polypropylene or polyethylene, toxic chemicals can
seep into land and water. Animals that eat plastic can strangle on it. In lakes, rivers, oceans,
it can harm fish, seabirds and other marine life that mistake it for prey. It also has potential
for greenhouse gas emissions and trans-boundary migration of organic micro pollutants
(dioxins and furans) and volatile heavy metals.

**E-waste:** This is a complex mixture of materials and components and needs careful handling
at all stages from manufacture to disposal. Batteries if improperly disposed can leach lead
and other toxic chemicals into soil and groundwater. These Several electronic manufacturing
operations involve coating a product, such as electroplating or painting. Chemicals are used
to strip off coating from rejected products so that they can be recoated. These chemicals,
which can include acids, caustics, cyanides etc. are often a hazardous waste and must be
properly managed.

In India, only 5% e-waste recycling is done formally whereas the rest is done informally.
Informal recycling of e-waste causes several threats to human health. E-waste products
can have over 1000 different substances, of which many of which are toxic, like lead,
cadmium, mercury, hexavalent chromium, plastic, PVC, BFRs, barium, beryllium, and
carcinogens like carbon black and heavy metals. These can contaminate soil and
ground water. They can cause severe health problems like liver, kidney and neurological
disorders in those handling the waste. PCBs, for example, contain heavy metals like
antimony, gold, silver, chromium, zinc, lead, tin and copper. The method of extracting
these materials from circuit boards is highly hazardous. Informal recyclers use primitive
and hazardous methods like acid stripping and open air incineration for processing e-
waste. These methods are highly unsafe and cause pollution by releasing toxins from
e-waste into the environment.
3.4.3. Creating sustainable wealth

Non-biodegradable waste disposal poses a major challenge to planet earth and civilization. Characteristics of various waste items determine the potential these have for wealth generation.

Recyclable waste: Those non biodegradable materials which can be put to use again in the same or different form – that is, reused, refurbished, or recycled – are known as “Recyclable Waste”. Inorganic waste, such as PET and plastics, waste paper and tetra packs are now increasingly recycled. These are used to create innovative products through organized or unorganized sector at micro or small scale. Recycling waste of useful materials puts them back into circulation for consumers. Large amounts of functional electronic items are phased out or discarded in favour of new models. These can be easily put to use. This would reduce the consumption of scarce and expensive resources/raw materials. It would also reduce consumption of energy. All these interlinks have positive impact on economy and environment.

Government has adopted new rules that provide for ways and means to minimize plastic waste generation, adoption of extended producer responsibility for collection of waste and sustainable plastic waste management, recycling and utilization of plastic waste in road construction, energy and oil generation.

Another form of recycling is salvaging or recovering certain materials from complex products. This could be

(i) Because of their intrinsic value, such as lead from car batteries or gold from circuit boards. Around 10% of total gold worldwide is used for their production.

(ii) Due to the intrinsic hazardous nature, such as removal and reuse of mercury from thermometers and thermostats.

Non recyclable waste: Those non biodegradable materials which can not be put to use again are termed as “Non Recyclable Waste”. Traditionally these are disposed off by (i) transporting to a distant site and dumping them in a landfill; and (ii) incineration or burning. Environmental concerns have led municipalities to develop better management of these wastes. Major initiatives have been launched to look at non recyclable waste as a resource to make energy. As an example, base liner systems are installed in landfills to prevent escape of leachate from waste into the environment. Installation of the leachate tank and methane extraction pipe allows these to be harvested as source of energy. Municipal Solid Waste Incinerators (MSWI) transform waste into solid ash that can be recycled for various applications. Energy is extracted from the hot gasses / fumes produced by generating steam in a boiler. This is used to turn a turbine to produce electricity. Development of flue gas scrubbing technology for MSWI cleans the toxic fumes before these are released into the environment.
All this contributes to resource efficiency and wealth generation through what is termed as a circular economy.

3.5. Logical Framework

The figure- 3.1 indicates the different processes for wealth generation from available wastes.

3.6. Waste management: An overview

All of us generate immense waste on day-to-day basis without being conscious of the neighborhood and the escalation of the problem. Our daily dump includes plastic bottles, plastic/Styrofoam cups, plastic carry bags, metal cans, tetra packs, metal scraps and construction debris of all kinds.

Most of us do not realize that much of household waste is non biodegradable. We generate and dump this waste along with the biodegradable waste without realizing the hazards this action poses. Non biodegradable waste such as commonly used batteries, aerosols, bulbs, fluorescent tubes, polishes, adhesives, household cleaners, drain cleaners, solvents, broken thermometers, medicines, syringes, discarded wound dressings, surgical gloves, diapers, sanitary pads, etc. contain harmful chemicals and require careful, and often specialized, handling.
**Waste Segregation:** The treatment of waste depends upon its nature and decomposition properties. Hence handling of waste requires segregation at source. A simple practice is to identify wet and dry waste being generated in the household and discard these in separate containers. Many households and communities now convert wet kitchen waste into compost, a product used for enriching soil quality.

The above wet-dry categorization of waste is not adequate. Wet and dry household waste can include potentially hazardous waste materials that should be segregated more carefully.
How long does it take to break down

- 2-4 weeks
- 3-4 weeks
- 6 weeks
- 8 weeks
- 3 months
- 4 months
- 1-3 years
- 5 years
- 10-12 years
- 25-40 years
- 30-40 years
- 50 years
- 50 years
- 50-80 years
- 450 years
- 500 years
- 500 years
- 200-500 years
- 600 years
- 200-1000 Years

Archeological Artefacts from Indus Valley Civilization (3300-1300 BCE)

- Brick Construction
- Bullock Cart: Terracota
- Bullock Cart: Metal
- Metal & Bone Jewellery
- Pottery: Baked Clay
- Stone Sculpture
- Terracota
Waste to Wealth: Crafting Useful Products

Amazing Construction From Recycled Materials
3.7. Waste Management

According to Central Pollution Control Board Report 2014-15, 51.4 million tonnes of solid waste was generated in the country. Of this, 91 per cent was collected, and 27 per cent was treated and remaining 73 per cent disposed of at dump sites. There is a critical need for developing sustainable wealth generating models for India’s waste. The potential is immense. It is estimated that India will have a waste management market to the tune of US$ 13.62 billion by 2025. With the concerted efforts of the government, increasing interest and participation of the industry, academia, not-for-profit organizations, and communities, the nascent waste management industry in the country is poised for a major turnaround.

The emphasis has to be on 100 per cent collection and scientific processing/disposal/reuse/recycling of municipal solid waste. To ensure the success of this vision, the government is focusing on providing all support to municipal bodies to come up with design, execution and operation plans for waste disposal systems. There is also an emphasis on private-sector participation and public-private-partnership (PPP) in capital expenditure and operation and maintenance costs for sanitary facilities. Industries are also increasingly cognizant about waste management, right from the point of production. Sustainable development sets the goal of redesigning the product to use non-hazardous materials.

Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange. A number of physical and chemical techniques are available to reclaim a waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. For example, a printed-circuit board manufacturer can use electrolytic recovery to reclaim metals from copper and tin-lead plating bath. However recycling of
hazardous products has little environmental benefit if it simply moves the hazards into secondary products that eventually have to be disposed of.

For anything to be a resource, it should be as clean and pure as possible. Therefore, to generate wealth, anything that is not useful in a particular location or for a person/s should be put away without contaminating it with other ‘waste’ or useless material. This is called ‘source segregation’. For instance, to make compost from ‘wet waste’ generated in homes, markets, educational institutions, hotels and restaurants or religious places, it must be ensured that it is not contaminated with ‘toxic waste’ such as batteries, paints, pesticides, mercury lamps and other hazardous chemicals. The quality of the compost then is excellent and by carrying out bio-methanation and composting, huge revenue from both the solid and liquid wastes can be realized.

Installing more efficient process equipment or modifying existing equipment to take advantage of better production techniques can significantly reduce waste generation. New or updated equipment can use process materials more efficiently producing less waste. Modifying existing process equipment can be a very cost-effective method of reducing waste generation. In many cases the modification can just be relatively simple changes in the way the materials are handled within the process to ensure that they are not wasted.
**BOX-I**

**Extracting Useful Products and Harvesting Energy from Non Recyclable Waste**

**Landfill**
The steps to construct a landfill are:
- Scientific Research about location of the site, geology, underground water level, location of the bodies of the water such as river and the density of the waste.
- Clearing the landfill site of all ground cover.
- Excavation of the ground (the volume of the excavation depends on the results of the first step).
- Construction of the berm all around the landfill site.
- Construction of the liner and leachate management system.
- Construction of High Density Polyethylene (HDPE) which avoids leachate to escape into the environment from the landfill.
- Installation of the leachate and methane extraction pipe.
- Installation of the leachate tank for each landfill cell.
- Installation of power plant generator and flaring system (for generating electricity) or compressor station (for selling methane itself)

**Incineration**
An Incineration facility processes waste in the following steps:
- Waste is dumped into a waste pit by dump trucks
- An overhead crane picks up the garbage from the waste pit into a hopper which feeds a moving grate that passes through the incinerator furnace
- The waste is set on fire by using 10 to 12 GJ of fuel
- 70% of waste sludge is evaporated
- An additional 1 GJ of fuel is used to reduce the production of hazardous compounds such as organo-chlorines
- Waste is transformed into solid ash and recycled for further application
- Energy is extracted from the toxic fumes produced by generating steam in a boiler
- Steam is used to turn a turbine to generate electricity
- Toxic gases pass through an electrostatic precipitator to allow the dust to settle
- The toxic fumes then go through flue gas and other cleaning systems before being released into the atmosphere through smoke stacks

**Plasma Arc Gasification and Vitrification** *(Vitrification is the transformation of a substance into a glass, that is to say a non-crystalline amorphous solid)*

A plasma arc facility processes waste in the following steps:
- Waste is received and weighed inside a containment building
- Large pieces of scrap metal and hazardous waste are separated from the waste stream
- Waste is shredded into small pieces and fed on a conveyor into a gasification vessel
- Process waste heat from the latter plasma arc conversion phase is used to gasify waste.
- Gas is fed into a plasma arc conversion vessel, where a plasma torch breaks the gas stream down at an elemental level, converting it to an energy rich synthesis gas.
- Fly ash is liquefied in a separate plasma vessel (vitrification process) and is cooled into a glasslike solid called slag.
- Synthesis gas is purified to separate toxic constituents
- Purified synthesis gas is used to fuel a reciprocating engine generator set.
- Excess process heat from the reciprocating engine and plasma arc vessels power a steam turbine to generate additional electricity
Problems with waste are as old as the human race. Generation of waste causes a loss of materials and energy. It increases environmental costs on society for its collection, treatment and disposal. Every stage in the life cycle of a product – from its initial creation to its final disposal – can create waste and environmental residuals. The 5Rs Principle offers a sustainable, environment friendly alternative to deal with the enormous challenge posed by waste with its obvious impact on human health, environment and natural ecosystems. It looks at waste as a resource at every stage of its life cycle. This defines waste hierarchy as a set of priorities for the efficient use of resources and underpins the objectives of waste management and wealth generation.

**Refuse:** It encourages the community to avoid unnecessary consumption and make informed life style choices by selecting items that use least packaging, require the least resources to produce, can be used multiple times. It promotes buying products that are recycled, recyclable, repairable, refillable, re-usable or biodegradable.

**Reduce:** It costs much less to make processes more efficient and prevent wastes from occurring than to later consume more energy and materials to capture the wastes and then to reuse, recycle, or dispose of them.

**Reuse:** It involves using resources in their existing forms without further reprocessing thereby minimizing additional labor, material, water, and energy required for recycling. For example, many household and industrial items can be repaired, re-used, sold or donated to charities, thereby keeping them in the productive economy

**Recycle:** It involves transforming resources into a form that can be used as an input to a new process i.e. taking a product or material at the end of its useful life and turning it into a usable raw material to make another product. (e.g., recovering aluminum or plastic from drink containers, reprocessing a by-product from a chemical process, or processing wastewater for secondary use).

**Recover:** Resource Recovery occurs after reduce, reuse and recycle have been attempted. It entails conversion of waste materials for the recovery of resources (such as electricity, heat, compost and fuel) or as metals, glass etc. through thermal and/ or biological means.

**Disposal or treatment:** Finally, the waste hierarchy recognizes that some types of waste, such as hazardous chemicals or asbestos, cannot be safely recycled and direct treatment or disposal is the most appropriate management option.
Consider a typical community with 1 lakh population.
- Average waste produced is 50 tonnes per day with 70% wet waste, i.e. 35 tonnes
- If all of the wet waste is composted directly or after producing methane gas, it reduces to 1/5th of its weight. Hence it will produce 7 tonnes of compost per day and 210 tonnes per month.
- If the compost is sold at Rs. 3/kg, it will yield Rs. 6,30,000 per month.
- Additionally about 3 tonnes of dry waste can be sold or converted into useful products everyday.
- The Urban Local Body can earn Rs. 7,50,000 per month or Rs. 90,00,000 annually.

On the other hand, for untreated waste, mixed solid waste management requires the municipality or corporation to spend about Rs. 700 per tonne, which is a minimum expenditure of Rs. 12,600,000 annually without any return on investment except pollution and ill health.
Waste to Wealth: The story of a zero garbage hamlet on India’s coast

Vengurla, a small municipality just half-hour drive from India’s tourist hub of Goa is an example of how a community can effectively tackle waste. It recycles every bit of the 7 tonnes of waste generated each day by the community. Converting its waste to wealth, it earns a hefty income, which is ploughed back into municipal activities. The project is led by Ramdas Kokare, the chief officer of Vengurla municipality under the aegis of United Nations Development Programme (UNDP). According to him, Waste is not a problem. It is the mixed waste and its segregation that is the real challenge. The highlights of this achievement are:

• Waste is segregated at the primary source of generation by households.

• 3,000 households separate waste in up to four different coloured bins. Municipal collectors pick up waste six days a week and transport it to the municipal dumping ground. The waste collection centre, has lush green gardens developed using organic fertilizer. Here it is further segregated by 20 workers in to 23 categories.

• Wet waste is used to generate biogas, producing 30 units of electricity per tonne. This powers all the machines in the dumping ground.

• One of the machines powered by the biogas is a plastic shredding machine. It crushes up to 180 kg of light plastic everyday.

• Used with bitumen, shredded plastic is effective in helping build sturdier roads that are able to withstand more wear and tear. These roads offer greater resistance to inclement weather, and reduce costs. A one kilo metre stretch of road can use up to 1 tonne of plastic or 1 million carry bags, and save INR 10,000 per stretch.

• Vengurla has 12 km of ‘plastic’ roads and earns Rs.15 per kg of plastic sold to contractors for road building in nearby areas.

• A briquette machine helps process dry waste such as cloth, paper, cardboard into briquettes, which are sold to nearby industries as alternate fuels for boilers.

• Heavy plastic is sold to cement factories where it is melted at 3000 degrees Celsius.

• Each month, the municipality earns Rs. 150,000 which is used to improve solid waste management systems in the village.

• The facility has drawn 7000 visitors so far.
3.8. Waste to Wealth: Some Examples from the Field


Prof. Alka Zadgaonkar and Dr. Umesh Zadgaonkar invented the process to convert waste plastic into useful products like furnace oil and LPG. The process is based on the principle of random depolymerisation and involves selective breaking of C-C bonds. Both plastics and petroleum derived fuels are hydrocarbons. However, the plastic molecules have longer carbon chains than those in LPG, petrol and diesel fuels. Therefore, it is possible to convert waste plastic into fuels. The process is a thermal selective splitting reaction of the large molecular weight polymer carbon chains under an oxygen free environment and produces small molecular weight molecules.

<table>
<thead>
<tr>
<th>Name of End Product</th>
<th>Quantity</th>
<th>End Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Hydrocarbons</td>
<td>600 - 800 gm</td>
<td>Agricultural pumps, D. G. sets, boiler fuel, marine fuel (bunker), input feed for petroleum refineries, Fuel oil</td>
</tr>
<tr>
<td>Coke</td>
<td>70-100 gm</td>
<td>Nearby industries using LPG, in-house consumption</td>
</tr>
<tr>
<td>Gas</td>
<td>Equivalent to produce net 2.25 units of electricity</td>
<td>Thermal power plants, metallurgical industries</td>
</tr>
</tbody>
</table>

Input: Carry bags, broken buckets and chairs, PVC pipes, CDS, computer keyboards and other e-waste.

Advantages:

- 100% waste is converted into value added products.
- Solution to the waste plastic problem, can change global economic scenario by saving millions of dollars in import of crude oil
- No preparatory cleaning or segregation
- Easy transportation of bulky waste
- Sulphur content in the fuel generated is less than 0.002 ppm
- There is no emission in the atmosphere or liquid effluents
- High quality of Liquid Distillate, matches de-sulphued crude oil

3.8.2. Bio-Methanation Plant at Koyambedu Wholesale Market

The Bio-Methanation plant was established in Koyambedu Wholesale Market Complex (Chennai, Tamil Nadu) as a unique national level demonstration project in order to utilize the organic waste generated from the perishables market for power generation. This project is a joint venture between Chennai Metropolitan Development Authority and the Ministry of Non-conventional Energy Sources (MNES) of Government of India. The plant is designed to handle about 30 Metric Tonnes of perishable wastes per day and will generate on an average of 2375 M³ of gas through ‘Bio gas Induced Mixing Arrangement’ (BIMA digester) to produce 5000 units of electricity per day. The energy production is being fed into the TNEB grid. The plant is functioning since 4 September 2005.


3.8.3. Polythene Recycling Unit by CEE

Plastic recycling is an alternative method to prevent plastic from entering our environment and thus, reducing the menace. Centre for Environment Education (CEE) has developed the ‘Polyloom’ which is a plastic weaving handloom that helps reuse and recycling of discarded plastic bags (polybags). The Polyloom is used to produce plastic woven fabric with different designs, which is then used to tailor and create finished products like bags, pouches, bottle holders, etc.

Source: Zero Waste System booklet published by Centre for Environment Education (CEE)
3.9. Project Ideas

Project – 1:  
Conversion of Leftover Mid-Day Meal to Animal Protein

Introduction
In a large number of schools across the country, mid-day meal is served to the school children. Out of the total amount of food cooked, an average of 10-15% is getting wasted. In a country like India where world’s highest demographics of children suffering from malnutrition and under nutrition related diseases, these leftover or food scraps (considered as waste) may be reused as food for animal that will become the source of proteins which otherwise create negative impacts on the ecosystem through decomposition and environmental pollution.

So for achieving green and clean environment around the school as well as efficient use of such leftover food vis-à-vis of cooked food, the study has been planned to use this as feed for some domestic animal which may become a source of animal protein for the poor community.

Considering the fact that many a communities living below poverty line (BPL) rear pig for their livelihood; and hence, this particular domestic animal may be considered suitable for the study.

Hypothesis
The leftover mid-day meal will help in growth and increase in body-weight vis-à-vis source of animal protein.

Objective
1. To study impact of food type on rate of growth and body weight of the experimental animal.
2. To compare the nutritional values of food materials consumed by the animal.

Methodology
Step- I
(i) Keeping record of type and amount of leftover amount of mid day meal for at least one month, considering holidays.
(ii) Gathering information on type and amount of food of animal provided by the local grower.
(iii) Calculating the cost of food per month
(iv) Calculating the food needed per animal for normal growth
(v) Analyzing nutrient values of both the foods (this can be done from some laboratory
**Step- II:**

**Experimentation**

The domestic animal ‘pig’ (piglet) has been considered for conducting this experiment.

**Material Required**

(i) 15 number of pigs of same breed and preferably of same age
(ii) 4 enclosures (2.5m x 2.5 m) with split bamboo to be constructed in some protected area (may be within school compound)
(iii) Food
(iv) Tray (4 numbers) for providing food – one for each enclosing areas.
(v) 4 containers for providing drinking water
(vi) Measuring tape
(vii) Plastic tags and thread
(viii) Notebook, pen, etc.

**Step- III**

(a) 15 number of pigs of same breed and age, selected for study, are to be divided into 5 groups consisting 3 numbers in each.
(b) The groups to be assigned identification marks with tag as ‘A’, ‘B’ and ‘C’, where
   • Group A will grow on waste mid-day meal
   • Group B will grow on Grower’s food
   • Group C is the control group of animal who will live on open field/range
     (These groups are termed as ‘Treatment’)
   **To avoid error all the three members of each of the groups to be tagged with indicative mark as P1, P2 and P3**
(c) The four cages are to be labeled randomly as A1, A2 and B1, B2.
(d) This is simply repetition of the treatment, known as replication.

(\textbf{Note:} For minimizing error in any experiment, the number of replication (or repetition) of the treatments should be minimum 3, but for convenience of the children and other constraints, here example has been given with two replications)

**Step- IV**

(i) At the beginning, children will put batches of 3 animals in each of the , leaving outside the rest 3 animals for control treatment.
(ii) Animals kept in the enclosures are to be allowed to stay within the enclosures with normal grower’s food for 4-5 days with the aim to acclimatized/ adapt the artificial living condition.
(iii) Children will take measurements of girth and body length (from neck to base of the tail) and record it in tabular form given below:

| Caution: The measurements must be taken in presence of some Veterinary Practitioner or some grower, having experience in handling the animal to avoid any harm to the children | 85 |
**Step- VI**

(i) Provide food treatment wise in the cages for 5 working days (i.e. from Monday to Friday); then provide the animal with grower’s food for 2 days (Saturday & Sunday).

(ii) Take measurements at the early hour on next Monday, followed by providing treatment wise food for next 5 working days.

(iii) After every day, similar measurements are to be taken as recorded in similar table.

**Step- VII**

(i) Considering the information (data) noted in Table-1 & 2, children will calculate body weight using the standard formula given below:

\[ W = \frac{(G^2 \times L)}{69.3} \text{ in kg} \]

Where, \( W \) = body weight in kg,

\( G \) = girth in mtr.

\( L \) = length of the body, in mtr.

The value 69.3 is the conversion factor from FPS to MKS system

(ii) They will compare the growth pattern with respect to control.

(iv) Data will be presented using simple statistics and mathematics.

(v) The calculated values to be noted in the similar table (shown below) and then they will put the mean values as well.

(vi) Convert body mass into protein using conversion factor as per ICMR or WHO standard.

(vii) The data should be analyzed using simple statistics.

**Conclusion:**

1. From the analyzed data, conclusion to be drawn if leftover mid-day meal is superior over grower’s food with respect to nutritive value and if it really help in improving really has impact on growth and development of pig, which will indicate increment in protein availability for the community as well.

2. The leftover mid-day meal which is usually dumped nearby school compound acting as breeding ground for mosquito and other insects can be stopped through transforming it to source of animal protein.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of A</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean value of C</td>
</tr>
</tbody>
</table>

**Table 1: Initial information on girth (in meter) of the animals**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of A</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean value of C</td>
</tr>
</tbody>
</table>

**Table 2: Initial information on body length (in meter) of the animals**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of A</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean value of C</td>
</tr>
</tbody>
</table>

**Table 3: Initial information on body weight (kg) of the animals**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of A</td>
</tr>
<tr>
<td>B</td>
<td>B1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td></td>
<td>Mean value of B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean value of C</td>
</tr>
</tbody>
</table>
Project – 2:

Organic Material to Compost

Food waste sealed in a plastic bag on a landfill site doesn’t decompose properly. Instead, it produces methane, a greenhouse gas, which contributes to global warming, as well as a liquid, leachate, which can contaminate water supplies. But composting your kitchen food waste is easy and requires little time, effort or space, depending on which system you use. The compost is invaluable for the soil in your garden or potted plants. It’s a complete and natural food for the soil, helping to improve its structure, water-retaining abilities and overall health.

Composting is simply the process of breaking down the organic matter (food waste) in the presence of air and water, using micro organisms and small insects present in nature. The end product is called compost which is rich in readily usable plant nutrients forming a part of healthy soil.

Materials which can be used for composting
- Vegetable and fruit peels
- Tea leaves and coffee grounds
- Crushed egg shells
- Grass cuttings and leaves
- Paper, paper towels and newspaper
- Leaves from non-coniferous trees and shrubs
- Wood
- Straw, hay, wool, sawdust and pets’ bedding
- Vacuum dust

Note: Avoid meat, fish, and cooked food, weed seeds, diseased plant material, disposable diapers, glossy newsprint and coal ash. Also avoid citrus fruit and onion peelings (which cause acidic conditions), plant seeds, meat, fish, dairy products, dog and cat droppings, spent tissues, diseased plant material and anything in excess.

Composting organisms require 4 conditions to create compost
1. Carbon that comes from brown organic matter like dried leaves, sawdust, paper
2. Nitrogen that comes from fruit and vegetable waste
3. Oxygen which comes from air
4. Water in the right amounts
Steps to compost your kitchen waste
1. Separate your edible kitchen waste (vegetable peels, fruit peels, small amount of wasted cooked food) in a container
2. Collect dry organic matter (dried leaves, sawdust) in a small container
3. Take a large earthen pot or a bucket and drill 4 – 5 holes around the container at different levels to let air inside.
4. Line the bottom with a layer of soil.
5. Now start adding food waste in layers alternating wet waste (food scraps, vegetable and fruit peels) with dry waste (straw, sawdust, dried leaves).
6. Cover this container with a plastic sheet or a plank of wood to help retain moisture and heat.

Every few days, use a spade to give the pile a quick turn to provide aeration. If you think the pile is too dry, sprinkle some water so that it is moist.

Within 2 - 3 months, your pile should start forming compost that is dry, dark brown and crumbly and smelling of earth.

By segregating, recycling and composting, a family of 4 can reduce their waste from 1000 Kg to less than 100 kg every year.

1. You can calculate the amount and percentage of compost produced out of the total amount of organic matter used.
2. Effective composting should have Carbon- Nitrogen ratio (C : N) in the range of 30:1 to 40:1. Carbon and Nitrogen content in the compost can be assessed using simple Soil Testing Kits.
3. One can identify the type and number of macro-organisms harboured in the final product (Compost). This can be converted into per cent or in any other suitable forms.

Project – 3:

Efficacy of Natural Additives in Recycled Paper for Use as Shelf Liner for Prevention of Infestation by Household Pests

Introduction
A common household problem is invasion by pests such as cockroaches, silverfish, ants, moths et cetera. No household is completely bug proof. The problem can be equally intense in densely populated urban areas such as in apartment blocks and attached housing as well as areas with lot of open land.

The efficacy of most commercially available household pest repellants that are available off the shelf is doubtful. They are potentially toxic and often pose a health hazard when they
come in contact with kitchen utensils, food items, clothing and stationery items stored in open shelves and closed cabinets. Traditionally, Indian homes have used plant based repellants to control the menace. For instance, dried Neem leaves are spread under a paper liner in wardrobes; neem and clove sachets are tucked strategically in storage drawers, even in rice and grain bins; strong natural oil extracts are applied to drawer corners as repellants. However, efficacy of these practices is not scientifically proven. Preventing infestation remains a global challenge.

**Objective**
1. To prepare recycled paper using commonly occurring herbs and natural waste material such as Neem (Azadirachta Indica) leaves.
2. To explore qualitatively the effect of “Herbal” Paper on common household pests such as ants, cockroaches and silver fish.

**Material Required**
Discarded paper notebooks or scrap paper, bucket, hot water, arrowroot starch, alum powder, measuring spoons, kitchen mixer/grinder, scissors, weighing balance, wire gauge sheet (60cm x 60cm) fixed in a thin wooden frame, (60 cm x 60 cm) pieces of fine muslin cloth

**Methodology**

**A. Preparing Neem Paper**
1. Shred used notebook sheets or scrap paper into small pieces. Put the shredded paper into a bucket, cover with water, and stir till completely wet. Leave over night to soak completely.
2. Grind the paper finely using the mixer/grinder available at home in small lots to make paper pulp. About 600 g of paper pulp is needed to make 6 sheets of recycled paper.
3. Take Neem leaves and grind to make 200 g of pulp using the mixer/grinder.
4. Take six bowls labeled as C, A1, A2, A3, A4, A5. Bowl C will be the 'control' paper pulp with no additive. Add the ingredients as given below and mix well.

<table>
<thead>
<tr>
<th>Ingredient (in g)</th>
<th>Bowl C</th>
<th>Bowl A1</th>
<th>Bowl A2</th>
<th>Bowl A3</th>
<th>Bowl A4</th>
<th>Bowl A5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Pulp</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Neem Pulp</td>
<td>Nil</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Arrowroot Starch</td>
<td>05</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Alum Powder</td>
<td>10</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
</tbody>
</table>

Now you have paper pulp with 5 different concentrations of Neem additive. Mix thoroughly.
5. Take the wire gauge strainer and spread the pulp from Bowl C evenly on it to make a sheet of paper. It helps to dip in a slightly bigger shallow trough of water to get an even
spread of pulp. Spread a muslin cloth slightly bigger than the size of the strainer. When the excess water has drained out, lift the paper sheet along with the cloth lining. Place on a hard surface (ply board or table) and press under a wooden board to smoothen the surface. Remove from under the board and leave it to dry hung on a clothes line in the sunshine. When dry, separate from the cloth lining.

6. Repeat the process to make paper sheets from the pulp containing Neem additive in the remaining bowls. It is also possible to place one sheet on top of the other along with the muslin lining and then press them all together to remove excess water. See figure.

7. When dry, label the sheets as C, A1, A2, A3, A4, A5. Trim the edges slightly to make these of equal size.

Table 1: Effect of Neem Additive in Recycled Paper on Insect Pest (Ants)

<table>
<thead>
<tr>
<th>Label</th>
<th>% Neem Additive (g)</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
<th>Day 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

B. Investigating the effect on household pests
1. Collect pests such as ants, cockroaches and silver fish and place in a bottle.
2. Spread the sheet of paper C on floor or a table. Place a counted number of pests on it. Observe their behavior to record the time spent by the pests on the paper. Record your observations on the motion in the Table 1 given below for a specific pest, repeating the experiment for at least 10 days.
3. You may take a video of the motion using your smartphone.
4. Repeat this with each of the papers labeled A1, A2, A3, A4, A5.
5. The experiment can be carried out for a longer duration to test the duration for which the paper with additive retains its property.
6. Repeat with other pests, recording observations in similar tables.

C. Effect of other herbal additives
Repeat the experiment making paper with other additives such as Pudina/ Mint leaves (Mentha), Ganjini/Malabar/Guchchh (Citronella grass), Haldi/ Turmeric (Curcuma longa), Orange (Citrus reticulata) peels, Lemon (Citrus limon) peels, Cucumber (Cucumis sativus) peels.

Record your observations in tables similar to that given above, for different pests.

Conclusion
From the above data, draw conclusions about which herbal paper is the most effective in repelling household pests. Some questions to answer are
(i) how effective different herbal papers are in repelling household pests?
(ii) what is the effect of changing the concentration of the additive?
(iii) how long does the paper with additive retain its property?
(iv) does each additive have the same effect on different pests?
(v) which additive is most effective for a particular type of pest?
(vi) if instead of paper sheets, herbal balls are prepared from the mixtures in Bowls A1, A2, A3, A4, A, would they be equally effective in repelling the pests?

Project – 4:

**Effect of Applying Different Waste Material as Mulches, on Population Density of Macro-Organisms**

**Introduction**
Macro-organisms such as earthworms are regarded as farmer’s best friend. They are responsible for soil development, recycling organic matter and form a vital component within many food webs. A mulch is a layer of material applied to the surface of soil for conservation of soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area. A mulch is usually, but not exclusively, organic in nature.
Objective
1. To identify different waste material that can be applied as mulch
2. To study about the effect of different material as mulch on earthworm population density

Materials Required
Seven sample plots of 1m x 1m in farm or garden soil; pegs and string, waste material to be used as mulch – coconut husk, fruit and vegetable waste, polythene bags – 1 kg per plot; weighing balance; spade, tray

Methodology
1. Identify the area where you will conduct the experiment- farm, kitchen garden, school garden.
2. Demarcate seven plots of 1m x 1m each keeping at least 1-2 m distance in between the plots.
3. Randomly label the plots as C, A1, A2, B1, B2, D1, D2
4. Plot C will be the ‘control’ plot while plots A1, A2, B1, B2, D1, D2 will be covered with different types of waste materials as mulch.
5. Each treatment will be replicated twice. (Note: The replication should be minimum 3 in numbers, but for convenience of the children and other constraints, here example has been given with two replications)
6. Begin by taking five random samples. Using a spade, dig upto a depth of 15 cm and collect the soil carefully along with all the macroanimals.
7. The collected soil is to be kept on a tray and of earthworms to be counted. Note their number in the given table 1. Reintroduce the soil back to the plot after the count.

<table>
<thead>
<tr>
<th>Table-1: Initial information on earthworm population density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample collected</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

8. The plots will be now prepared for experiment. Apply coconut husk mulch to plot A1, A2. Apply vegetable and fruit waste mulch to plot B1, B2. Apply shredded polythene bag to plots D, D2.
9. Observations are to be taken over a period of one month. After each week, soil samples are to be collected from each plot for counting earthworm population and are to be recorded in Table 2.
10. The next step is to compare the population density with respect to control.
11. Data will be presented using simple statistics and mathematics.
Table 2

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of Earthworms present</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 1</td>
<td>Week 2</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Conclusion**

From the analyzed data, conclusion to be drawn if different mulch has any effect on population density of macro organisms.

**3.10. Additional Project Ideas**

1. Fuel from Animal excreta such as cow dung, bio fuels
2. Handling of E-Waste
3. Identification, documentation & classification of the amount of electronic and electrical goods left unused in one’s locality & look out for means for disposal and/or re-use.
4. Solid waste processing and disposal
5. Preparing Briquettes and checking efficient use for soil less plantation
6. Minimizing wastage of irrigation water through improving water retention in the soil using various wastes eg. wood shavings, briquettes, paddy husk, coconut choir, etc.
7. Bio remediation of waste water
8. Hydroponics using grey and/or black water
9. Treatment of kitchen waste water for removal of Fat, Oil Grease
10. Preparing natural dyes from leaves, flowers, fruits of weeds
11. Conversion of discarded flowers into useful products
12. Extracting oil from the seeds of weeds, to be used for illumination
13. Retention of soil moisture using wood shavings, briquettes, paddy husk, coconut husk, hyacinth in crop fields
14. Using paddy straw as substrate for mushroom cultivation
15. Use of Graphite from used batteries (dry cells)
16. Enhancing fertility of land using various wastes
17. Plastic decomposition by bacteria
18. Investigating properties of sponge for water retention and growing plants
19. Use of thrown away corrugated cardboard for making of tiles, panel boards, etc.
20. Preparing tiles and panel boards from tetra pack/ plastic bottles
21. Preparing fertilizer & other useful products from the carcasses
22. Innovative techniques for converting agriculture wastes into useful products
Survey based projects
1. Finding out the average waste generated per day at home. Extend the estimation to waste generated by the block, village, district, etc.
2. Study the packaging trend and estimate the associated wastage
3. Monitoring air quality around waste landfill and garbage dump areas
4. Diversity of organisms/ animals around land fill areas and linkage to vector borne diseases.
5. Impact of polluted water due to presence of waste dumping sites on public health

Information Sources
  (Retrieved on 27 June 2017)
- https://pearl.niua.org/sites/default/files/books/GP-IN3_SWM.pdf
  (Retrieved on 25 June 2017)