IRTC

Centre for Excellence in
Waste Management

ESTABLISHMENT OF
CENTRE OF EXCELLENCE IN WASTE MANAGEMENT

Project under
GRANT-IN-AID (NON-PLAN) SUPPORT
(2016 April to 2019 March)

Kerala State Council for Science,
Technology and Environment
Government of Kerala

INTEGRATED RURAL TECHNOLOGY CENTRE (IRTC)
MUNDUR, PALAKKAD, KERALA

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REPORT

INTEGRATED RURAL TECHNOLOGY CENTRE
Mundur, Palakkad, Kerala

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FOREWARD

Right from the inception, a priority agenda in IRTC activities was recycling of waste and dissemination of related processing technologies to the public. Such initiatives gained momentum in IRTC during Peoples Plan Campaign with the successful implementation of a project in 1999, to construct, operate and transfer a solid waste management plant in Chalakkudy Municipality for the treatment of bio-wastes by windrow and vermi composting. Since then, during the span of one-decade, IRTC has promoted composting devices and biogas plants among the people which can treat a total quantity of 455 tons bio-wastes per day which is roughly 4% of the total bio-wastes generated daily in the State. This was achieved through the collective efforts of its Project Implementation Unit and Parishath Production Centre. IRTC earned the status of an accredited Agency in solid waste management in 2003 and is the recipient of the 3R Excellence Award 2018 for Civil Society Organizations instituted by the 3R Forum in Asia and Pacific.

IRTC's growth as an institution that is involved in the technology dissemination in waste management necessitated the expansion of laboratory and training facilities. Studies for generating locally specific data were also needed to help the preparation of detailed project reports for Local Bodies. Therefore, IRTC submitted a 5-year proposal for fund support to improve Research and Development facilities, based on which a non-plan grant was awarded by the Government of Kerala in the annual budget 2016-17. IRTC was directed to submit a revised proposal for 3-years to KSCSTE for availing the grant. Accordingly, a project entitled 'Establishment of Centre of Excellence in Waste Management' was submitted to KSCSTE and IRTC received a fund support of Rs 150 lakhs during 2016-2019 period.

A portion of the fund was utilized for infrastructure improvement for developing compost yard, bio-energy yard, wastewater treatment systems and material Recovery Facilities for plastic and e-wastes. These facilities are being used in a big way for training purposes. By providing essential instruments and equipment in the Microbiology and Environmental Laboratories, the Research and Development activities also improved in its content and coverage. A team of researchers are engaged under proper guidance for this purpose. Development of inoculums for the activation of composting and bio-methanation can be cited as a major output.

This report is a compilation of the activities in CEWM during 2016 -2019. The details are furnished in nine sections. The fund support has given tremendous strength for the service delivery in waste management sector from IRTC.

Dr.S.Sreekumar
Director

EXECUTIVE SUMMARY

As an accredited agency for solid waste management, IRTC has been extending state-of-the-art technologies to LSGs, since 1999. The three-year (2016-19) grant-in aid (non-plan) support from Govt. of Kerala, helped IRTC to establish infrastructure facilities for R&D activities in solid and liquid waste management under the project title 'Establishment of Centre of Excellence in Waste management (CEWM)'. This has led to the consolidation of related activities in IRTC under one roof and delivering community services through out the state.

The fund was utilized partly for strengthening the infrastructure that would provide experiential learning situations for different target groups. This include bio-park, compost yard, bioenergy yard, grey-water and blackwater treatment systems and an Material Recovery Facility for plastic and e-wastes.

The compost yard displays composting systems that are endorsed by the Suchithwa Mission in its Technology Handbook. The approach towards treatment technology is process centric and not device centric. Caring microbes has always been the key to meaningful bio-processing. This principle is used in the development of microbial inoculums. Low-cost composting systems are displayed here to illustrate this. On an average 10 to 15 tons of high-quality composts are produced annually in CEWM compost yard and steps have been taken to market it.

The CEWM has developed an inoculum to be used as composting accelerator at a dosage of 5 L per ton waste. It is applied in liquid form by spraying while wastes are shredded, followed by the addition of coir pith to absorb excess moisture. The inoculum is effective for composting chicken slaughter wastes also. Studies on the co-composting of fiber rich bio-wastes such as plantain leaves were conducted and treatment protocol suggested. Agro-residues other than coir pith are also prescribed as moisture absorbent additives in composting.

The bio-energy yard maintains biogas plants that cover both portable and fixed models. The division maintains waste-to-energy bio-digester systems which are suitable for domestic as well as community level use. A toilet linked biogas digester is also functioning for research and training purposes. Besides, the bio-energy installations give an average yield of 9m^3 biogas per day for cooking. This corresponds to about 3176m^3 biogas annually and can replace 91 LPG gas cylinders of 14.2 kg. Part of the biogas is used for lighting purpose in the campus.

The CEWM has developed an inoculum which can partially replace cow dung for the activation of biogas plants. Institutions such as Government Engineering College, Kannur, has made academic collaboration with IRTC for using bio-energy facilities in our Campus. 24 days training for JEEVIKA, an organization like KUDUMBASREE functioning in Rohtas district, under DRDA, Government of Bihar, was conducted from 16th December 2018 to 8th January 2019. They were trained in fabrication, charging, operation and maintenance of 2m^3 biogas plants. Apart from this, the Green Energy Division of the Pondicherry University availed the services of the

CEWM for establishing bio-energy units for strengthening their academic programmes.

Studies are ongoing for decentralised management of faecal sludge using prototypes of multiple feedstock bio-reactors. Development of toilet linked digester models suitable for waterlogged areas are progressing. A work plan is ready on the design, fabrication and maintenance of flood resilient toilet linked Multi-feed Biogas Reactors.

Moving Bed Bio-film Reactor (MBBR) was retrofitted without altering the existing anaerobic biogas digester and clarifier tanks, by providing an extra collection tank in between. About $3m^3$ biogas is generated daily from the anaerobic tank and is being used for cooking. The system is being used for both training as well as for investigative studies on the performance of the MBBR.

The financial supports from KSCSTE has helped the up-gradation of the Environmental Laboratory. As part of this instruments such as AAS, COD Analyzer, IR digestion unit and UV-Spectrophotometer were installed for quality control of drinking water, greywater, wastewater and compost manure. The laboratory is an accredited Centre of the Kerala State Pollution Control Board. A good microbiology lab is also maintained. Production and supply of inoculums are a continuous activity here. Three inoculums are developed, others are in the pipeline. Investigative projects, dissertation and internship for students and researchers from various Institutions are carried out in the Centre.

Activity based learning is a speciality of the CEWM and provide training support for waste management initiatives of the State Government. Practical training in liquid waste management has been introduced recently. Trainings and transfer of technologies from CEWM are done now with better sense of purpose than did ever before. CEWM provides training and technology transfer to many institutions. KILA avails training facility regularly from this Centre.

Community compost plants are operated in various LSGs in hub and spoke model with the technical support of CEWM. Four Government Medical Colleges in the state are at the receiving end of technical support from CEWM for their campus wastes management.

Dissemination of information is a major activity of the Centre. A book authored by the Head of the Department of CEWM, on waste management was published by KSSP, 3rd edition of which is under circulation now. Two booklets, training-modules and several articles on waste management were published during the report period. A research paper prepared on facultative bacterial inoculum sent for publication in the Indian Journal of Microbiology following the approval of the abstract in February 2019, is under review. A paper on the application of microbial consortium as composting accelerator was presented in the 4th India International Science Festival 2018. Alternate materials to support green protocol have been designed and promoted by different divisions of IRTC. The microwavable clay pot is an example.

The CEWM is supported by an advisory committee consisting of senior faculty and researchers. IRTC was the recipient of the 3R Excellence Award for Civil Society Organizations for 2018. A certificate of appreciation for exemplary work in the area of waste management through 3R (Reduce, Reuse and Recycle) was awarded in a function of the 8th 3R Forum in Asia and Pacific, held at Indore during 9-12 April 2018.

PREFACE

Having attained the Open Defecation Free status, the State is doing its best for attaining the safe standards for the treatments of faecal sludge, wastewater and solid wastes. Disadvantaged by frequent disease outbreaks, severe pressure on land and the impracticality of centralized disposal and treatment facilities, the State is relying heavily on decentralised waste management system. Following the updating of all relevant Rules and enactments of Policies by the Central Government, Kerala is closely on heels in releasing Sanitation Strategy, Policy on SWM and Guidelines on Integrated Wastewater and Septage Management.

Segregation, treatment at source, collection and channelizing aided by campaigns and action programmes are the need of the hour, their success being depended on transformation of the habits of people. Viable technologies are available for on-site treatment of bio wastes and community level treatment of spill over wastes. Priority must be given to recycling and not disposal. Technologies that ensure user acceptance, economy and efficiency should be preferred to mere burning practices of organic and plastic wastes. Humification of organic waste is a human bondage to nutritional security of soil and so no organic wastes shall be burned. Plastic recycling industry enjoys a comfortable economic base and so thermal options become relevant only at the end of their extended life through recycling or reuse. Green protocol will reduce the management burden further, provided people opt to practice it.

Faecal sludge management is a big challenge especially when we look for flood resilient toilet systems. Grey water treatment systems are inevitable because the State is in the process of rapid urbanization. Orienting people to new sanitary practices is not a mean task. There is need to integrate waste management practices with farming, land, water and lifestyle.

Waste related dogma, prejudice and cynicism of people remain strong and only stronger interventions can break the ice. It is here that Peoples Organizations can link Government Institutions. Data base, guidelines for meaningful participation and hands on trainings are essential for effective service delivery. In short there exists a huge demand for vibrancy in technical and institutional service delivery and for engendering receptivity among people.

IRTC which has decade's long R&D experiences in waste management is one of the most appropriate Institutions in the State that can join the fray making use of the mass base of KSSP, its parent organization. The special grant assistance was a blessing in bloom for strengthening the service delivery as well as improving their quality and content.

PROFILE OF IRTC

Integrated Rural Technology Centre (IRTC), Mundur, Palakkad, is a knowledge-based technology dissemination Institution established by the Kerala Sasthra Sahithya Parishath (KSSP) in the year 1987. It is a grand-in-aid Institution and received core support grant from the Central as well as the State Governments through DST and KSCSTE. IRTC is one of the accredited Institutions that cater to the demands of waste management in Kerala. Among the three functional Units of IRTC, the parent unit undertakes R&D activities, the Parishath Production Centre attends production activities and the Project Implementation Unit do that work for Local Bodies. It maintains two campuses having a total land area of 2 hectares. Infrastructure include smart training halls, food and stay facilities for 400 persons and divisions such as Solid and Liquid Wastes Management, Natural Resource Management, Energy, Pottery, Mushroom, Food processing, Project Implementation Unit, Samata, Aquaculture, Training, Social Science.

R&D activities in Waste Management began during Peoples' Campaign for Local Development and Planning in the 90s. Earth worm composting and toilet linked bio-methanation were some of the early works. Windrow and worm composting systems established in Chalakudy Municipality in 1999 through an IRTC-project was the first attempt of that sort in Kerala which prompted other LSGs to chase that track. Low cost composting devices as well as live earth worms were popularized among farming communities to transform wastes to wealth. A notable R&D work was done on pipe compost. When introduced, pipe was meant for anaerobic treatment with airtight cap which soon became unpopular due to worm growth. IRTC modified the device and made it aerobic, ensuring user acceptance through trainings. IRTC has been offering service support to about 60,000 units of improved pipes and 10,000 units of other devices such as earthworm compost and aerobic composting devises including low cost earthenware and ferro-cement pots. Together they process about 70 tons bio waste in a day.

Design, fabrication, installation and maintenance of portable, fixed dome and floating drum biogas plants in the feedstock range of 2.5 kg per day domestic models to 2000 kg per day institutional models are undertaken by IRTC since 1999. In all about 10,000 domestic biogas plants (0.5 m3, 0.75m^3 and 1 m^3) have already been installed providing maintenance services and about 40 tons of bio-wastes are thus recycled daily. A notable achievement is the successful operation of 6 biogas plants having a total feedstock capacity of 10 tons per day in the Government Medical College, Kozhikode, since 2011. Government Medical College, Thiruvananthapuram, has installed 6 biogas plants for fermenting 2600 kg waste per day and operating successfully since 2017. Four milk plants under MILMA are maintaining IRTC biogas units installed in 2015. In all about 54 tons per day organic wastes are being fermented now through IRTC supported biogas systems state-wide and the biogas yield is roughly 2100m^3 which is equivalent

to 60 LPG cylinders of 14.2 kg.

Since 2011, IRTC promotes toilet linked and animal waste fed fixed dome stationary biogas plants with digester tanks strong enough to resist permeability of water.

During the span of the last 16 years, IRTC-promoted bio waste treatment systems grew to a capacity of about 455 tons per day which is about 4% of the total daily bio wastes in the state.

The $2m^3$ grey water treatment unit installed in 2012 in IRTC is operating on conventional Waste Stabilization Pond System. They are maintained for the purification of overflow wastewater from kitchen and biogas plants.

Environmental Laboratory has facilities for microbiological as well as chemical analysis and they support R&D activities. Studies on inoculum are going on. Facilities are also there for coli-form bacteria detection. Biological and chemical analysis of drinking water, wastewater and compost samples are done regularly. The water quality testing laboratory is approved by the Kerala State Pollution Control Board for delivering services to the public.

Students from various Universities in Kerala and Tamil Nadu have been utilizing the facilities in IRTC, including the guidance from experts, to do their obligatory research projects on waste management for the partial fulfilment of their course work.

Trainings are being offered from IRTC in bio-processing technologies as per the demands from Local Bodies, Institutions and Agencies. Kudumbasree workers, service technicians, Local Body functionaries, LSG officials and students have been the beneficiaries of skill development trainings.

Steps Towards Establishment of Centre of Excellence

The status of IRTC as an accredited agency since 2011 guaranteed its competency in the service delivery to LSGs in waste management and allied activities. Beyond the responsibilities such as preparing DPR for design, fabrication and Operation protocol, an accredited agency like IRTC must be duty bound to keep abreast of the current trends in the technologies for waste treatment. This in turn needed a team of researchers under sustained guidance to study and generate data base. Moreover, investigations, appraisal and transfer of innovative technologies, required updating of facilities in IRTC from time to time. Research projects done with fund supports were target-specific and they seldom gave room for infrastructure build up. The limited space in the waste processing yard became inadequate to satisfy the growing demands from waste management sector. LSGs demanded skill development and capacity building trainings for which demonstration of technologies prescribed by the Suchithwa Mission in its Technology Handbook, Guidelines and Specifications became inevitable.

Once the Central Laws were revised in 2016, 'producer pay' and 'my waste my responsibility' principles came into being and time bound responsibilities were fixed on the governance system. The horizon of trainings thus widened, and its trajectory grew from segregation, storage, collection & transportation, treatment to channelizing of wastes such as plastic, e-wastes and domestic sanitary wastes. The Law demanded material collection, storage and resource recovery facilities for all wastes and so design, construction and entrepreneurial management of MRF became felt needs in trainings. No such facilities existed for demonstration purpose.

Wastewater and faecal wastes management turned out to be the priority areas in the sanitation strategy. Demonstration of their treatment technologies emerged yet another prerequisite for IRTC based trainings. The toilet linked biogas promoted by IRTC were innovative models in FSM, however, the usual problem of desludging needed further studies for prescribing a viable solution.

The microbiology and environment lab also needed expansion and updating to ensure facilities for research that would generate data base for technology dissemination and skill development to meet emerging trends in the waste management sector. Investigations on microbial supplements were constrained by the limited lab facilities and so outsourcing often became inevitable. The objectives set for availing the non-plan grant took into consideration all the above facts.

Mandate for availing non-plan grant

IRTC submitted a 5 year research and development proposal to the government of Kerala requesting financial support for improving facilities and strengthening its activities in the waste management sector. Considering the profile and talents of IRTC in the field of waste management for over two decades, its present status as accredited institution and the need for strengthening the Research and Development activities, the Government of Kerala in its Annual Budget for the year 2016-17 awarded an amount of Rs.50 Lakhs, in the form of a non-plan grant routed through KSCSTE. Following this, IRTC was asked to prepare a revised DPR specifically for a period of 3 years from 2016-17 to 2018-19 and submit the same to KSCSTE. IRTC submitted a project entitled 'Establishment of Centre of Excellence in Waste management (CEWM)' with well-defined objectives to be fulfilled during the project period ensuring its benefits to the people. After fulfilling the mandatory formalities for the approval of the project the KSCSTE released the budget allocation for three years.

Project Objectives

1	To elevate IRTC as training Centre for capacity building and skill development in waste management by improving infrastructure and allied facilities.
2	To elevate IRTC environment laboratory as a support Centre for research in waste management.
3	To promote studies on inoculums to be used as accelerators in composting and in fermentation.
4	To conduct studies on toilet linked biogas and faecal sludge management.
5	To develop innovative technology practices and transfers them to LSGs and Academic Institutions for sustainable operation and maintenance.
6	To evaluate, document and improvise selected composting as well as biogas units that were installed by IRTC and suggest a service provider system and protocol.
7	To provide trainings targeted to various groups with a view to improving the quality of Peoples participation in waste management.

I. PROJECT OUTPUT AND ACHIEVEMENTS
(2016-17 TO 2018-19)

1. INFRASTRUCTURE

a. Compost Yard

The renovated compost yard is in a land area of 5 cents and a building having a plinth area of 125 m^2 accommodates working models of composting devices authorised in the Technical Handbook of Suchithwa Mission. Vegetable shredder and sieving machine are provided. Wastes are procured from vegetable market and a wholesale distributor of fruits. Space for learning by doing, demonstration and observation are available to accommodate 25 people at a time.

Renovated
Compost Yard in CEWM

Earth Worm
Compost unit in CEWM

i) Household Composting Devices in CEWM

The highlight of the exhibits is the encouragement that it provides to people to go for low cost or even zero cost devices made of locally available containers, rather than going for costly and attractive devices on subsidy basis.

Pipe Compost

Ring Compost

Bin Compost

Bin Compost

ii) Kiosk of Composting Devices

Kiosk of composting devices in CEWM

The purpose of kiosk is to take people into confidence to use low cost composting devices in their households. Kiosk can generate trust and interest to set up source-treatment systems for domestic organic wastes. Kiosk provide choice of devices from among the collections, according to the need and interest of the people. The guidelines released by Suchithwa Mission stipulate that such devices must be exhibited in the form of kiosk in Ayalkoottams, Gramasabhas, street corners and such other places.

Production and sale of earthworm and vermi compost is a dominant work in the compost yard.

Compost sieving machine in CEWM

50kg/hour Vegetable shredder in CEWM

b. Bio-Energy Yard

Bioenergy yard is in 2 cents open area where facilities for doing experiments using 1m³ plants in 20 units at a time are available. Energy evaluation and gas yield studies are done in a lab having a plinth area of 25m² which is provided in the vicinity itself. Learning by doing in aspects such as installation, operation and maintenance of biogas plants as well as their fabrication and assembly are possible in the CEWM bio-energy yard.

Bioenergy yard in CEWM

i) Institutional model floating drum biogas plant

Institutional model floating drum biogas plant having 6m³ digester capacity (10m³ plant) was renovated for demonstration training purpose. Its feedstock capacity is 50 kg per day and gas yield is 2m³ per day. Biogas purification assembly is attached to this unit. Iron filings filter trap for hydrogen sulphide removal, water trap for ammonia removal and quick lime trap for moisture removal are provided specifically for research and demonstration purposes. Purified biogas fired turbine generates electricity and power. These are additional facilities attached to this plant. While the power is utilized for running motor, the electricity is used for lighting in the kitchen. Only 30% of the biogas from the plant is used for the above said purposes. The remaining 70% biogas is used for cooking.

Kitchen Waste fed Floating Drum Biogas Plant in CEWM

ii) Community model latrine linked biogas plant

Community model LLB has a digester volume 11.2m^3, waste retention space 8.7m^3, gas-holder area 1.68m^3, septic tank 1.62m^3, anaerobic filter tank 9.1m^3 and sock pit 1.4m^3. This unit was commissioned in 2013 at a cost of INR 6.5 lakhs. This plant was modified, and additional facilities provided for the purpose of demonstration training. The plant has connectivity to 25 latrines and captures excreta of 100 persons per day. Besides, food wastes are also fed into it. Feedstock capacity of the plant is 100 kg per day. The gas yield is 10m^3 per day and is used for cooking. It provides an opportunity for trainees to shed their dogma on using human excreta derived fuel for cooking.

Community Latrine Linked Biogas Plant (LLB) in CEWM

iii) Household model latrine linked biogas plant

Household model LLB has a capacity of 2m^3 digester volume, 1m^3 displacement tank and 1m^3 sock pit. It is an all-in-one latrine linked model having 20 kg feedstock capacity and gas yield 1.5m^3 per day. It was constructed in 2018 attached to a family quarter using ferro cement at a cost of INR 40,000 for demonstration training.

Household model latrine linked biogas plant in CEWM

c. Grey water treatment facility

i) Grey Water Treatment activated sludge baffled reactor

The greywater treatment plant of 5m^3 installed capacity was constructed in 2013 in the vicinity of IRTC kitchen for treating wastewater using baffled activated sludge process. The efficiency of the plant was far from satisfactory.

Grey Water Treatment activated sludge baffled reactor in CEWM

ii) Grey Water Treatment MBBR technology

Moving Bed Biofilm Reactor (MBBR) was retrofitted without altering the existing anaerobic biogas digester and clarifier tanks, by providing an extra collection tank in between. About 3m^3 biogas is generated daily from this plant and is being used for cooking.

The purpose of MBBR attachment was to bring the quality of treated water to stipulated

Aerobic Moving Bed Biofilm Reactor for grey water treatment in CEWM

standards. Since the aerobic clarifiers were inefficient, the outflow water suffers malodour and high BOD. Both the collection tank as well as the MBBR that were retrofitted have 2m^3 water holding capacity.

The MBBR is a state-of- the-art technology for wastewater treatment. The system is fully automatic and regulated for 4-hour HRT. Round the clock aeration is provided in 3 clarifier tanks. Poly aluminium chloride and sodium hypochlorite solutions are added for inducing sedimentation. The sediments are pumped out. The overflow water is further purified in sand and charcoal filtration. The treated water is used for irrigation. The whole system is compact and needed only very little space. The MBBR assembly is installed under a roof and have enough ground space for demonstration trainings.

MBBR retrofitting of this sort might be required in improving the performance of several activated sludge-based wastewater treatment plants that exist in the state.

The MBBR plant-based demonstration trainings are highly appreciated by LSGs. Investigative studies are underway in IRTC on the plant performance. Models of leach-pits are also maintained in IRTC.

iii) Leach-pit

Leach Pit Model in CEWM

d. Material Recovery Facility for Non-biodegradable wastes

MRF is a facility for the interim storage of cleaned and dried plastics and e-wastes before they are channelized to authorized recyclers. The government guidelines prescribe 1000sqf storage space for every 10,000 population. IRTC constructed an MRF in accordance with this specification providing interior storage facility for segregated wastes.

Material Recovery Facility (MRF) in CEWM

It exists in 2.5 cents land and have 95m^2 plinth area. Cabins are built using iron-net and angle-iron to a height of 1.8m from floor. Plastics are segregated primarily on their resin number and again based on thickness, print or no print and colour. Segregated items are stored in 84 cabins to demonstrate the scope of recycling.

MRF interior

IRTC now maintains mechanized MRF by installing plastic-shredder and extruder. The RPM of the motor and the specifications of the cutting blade are governed by plastic type. The extruder performance is governed by the melting point of each plastic type. The concurrence of an authorized recycler would be ideal before using such equipment for facilitating further value addition. Demonstration training emphasize all these aspects.

60kg/hour Plastic shredder in CEWM

3 to 10kg/hour Plastic Extruder in CEWM

e. Wood burning highly efficient Kiln

A waste to energy gasifier unit has been constructed in IRTC/ PPC campus. This is suitable for safe incineration of non-recyclable plastics for utilising the thermal energy in them. This waste to energy plant provides an environmentally safe thermal option for the disposal of sanitary wastes such as napkins, diapers and other infectious wastes. The furnace temperature guaranteed is 1252^{0}C. Performance evaluation is done by monitoring the furnace temperature using thermo cou-

Waste to energy gasifier (അതിതാപന ചൂള) in PPC-IRTC

Thermo couple for temperature measurement

ple. The maximum temperature observed is in the zone of second stage burning of initial gases in the upper zone of the furnace. The flow gas mainly contains carbon dioxide steam and oxides of sulphur and nitrogen.

f. Laboratory facilities

An additional floor space of 220m^2 was set apart for the expansion of the laboratory. An air-conditioned room was provided for keeping sophisticated instruments. Three phase connections and allied utility services were provided. Instruments such as Atomic Absorption Spectrophotometer and Automatic Nitrogen Analyser having Infra-Red digestion and distillation assembly were installed. Heavy duty oven, pH meter and UV Spectrophotometer were purchased to meet additional requirements. Microbiology lab was set up separately with A/C facility.

Atomic Absorption Spectrometer in CEWM

COD Meter in CEWM

Automatic Nitrogen Analyzer in CEWM

Environmental Laboratory in CEWM

Hot Air Oven in CEWM

Laboratory Centrifuge in CEWM

Autoclave in CEWM

UV Spectrophotometer in CEWM

Microbiology Lab in CEWM

2. TECHNOLOGY INNOVATIONS

a. Studies on Microbial Inoculum

Inoculums are microbial supplements used to accelerate bio degradation of wastes. Bio wastes consists of both storage and structural organic compounds. While the former is vulnerable to microbial degradation the latter degrade only slowly. Commercial inoculums help degrade fibre components in organic wastes relatively more and thus increase the net yield of compost.

Two research projects funded by KSCSTE under RTP have specifically paved the way for inoculum-based research in IRTC. The first project entitled "Studies on the effectiveness of EM in accelerated composting to promote bio waste recycling in rural areas" was completed in February 2016. Another study on the "Effectiveness of bacillus species enriched EM solutions as partial substitute for fresh cow dung in the installation and stabilization of biogas plants" was completed in March 2018.

Inoculum-based studies began in IRTC with the quantification of the lignocellulolytic activity of cow dung isolated Bacillus species bacteria that survived both mesophilic and thermophilic conditions, at an optimum dosage level of 5 L inoculum (1x108cfu/ml) per ton of organic waste. Enhanced compost yield in limited processing period of about 40 to 45 days was obtained.

Further investigations through 16S r-RNA genomic test, revealed that the inoculum contained *Bacillus subtilis*, the fermentative bacteria that can survive 126 days shelf life and active under aerobic, semi-aerobic and micro-aerobic conditions, not only in compost piles but in biogas digestors as well. The additional facilities in microbiology laboratory for conducting experiments on inoculum were provided from special grant assistance. Genomic analysis was done in KAU and SciGenom Laboratory, Cochin.

The inoculum called BACIplus-1 is recommended at 5L per ton waste and its production now is limited to the capacity of the microbiology lab and to cater to the demands in compost plants run by IRTC/PIU. The inoculum costs about Rs.110/- per litre.

BACIplus-1

BACIplus-1 in coir pith

The inoculum BACIplus-2 contains spore forming facultative bacillus subtilis (1x106cfu/ml) and is recommended at 40ml/kg cow dung withdrawn, limited to a maximum withdrawal of 3/4th of dung used now, for initial charging of biogas plants. It

costs about Rs. 120/- per litre. This inoculum is effective in windrow composting because of the anoxic zones that exists in the interior portions of the waste pile.

The inoculum PLEUROpith-1 contains Pleurotus florida spawn (1x106cfu/ml) and is being experimented now at 3kg per ton coir pith for solid state pre-treatment, before being applied as moisture absorbents in compost pile along with inoculum supplements.

Twelve bacterial isolates with oil degrading potency were recovered from oil trap assembly in sewage treatment plant. Seven non-pathogenic isolates from among them are under scrutiny.

Investigations on cow dung based fungal species to be used as composting accelerators are progressing. Out of the 7 isolates screened, Aspergillus species is identified and its competitive inhibitory tests and hydrolytic activity on lignocellulosic matter are under examination.

A research paper prepared on facultative bacterial inoculum sent for publication in the Indian Journal of Microbiology following the approval of the abstract in February 2019, is under review. A paper on the application of microbial consortium as composting accelerator was presented in the 4th India International Science Festival 2018.

The production capacity of inoculum in IRTC microbiology lab at present in 20L per day. This is enough for application on 4 tons bio wastes. Liquid inoculum is sprayed on the waste while shredding and then mixed with dry coir pith for regulating moisture in windrow composting. In household composting devices, inoculum is applied in compounded form in coir pith. The yield of compost varies in the range of 55 to 60 % by weight and is obtained in 40 to 45 days. In-situe multiplication of the microbes is also successful. This is done by mixing 15-20 days old compost material in which inoculum was sprayed at the beginning with fresh wastes. If this practice is continued the use of inoculum and coir pith can be reduced.

Bacillus Subtilis

PLEUROTUS

BACIplus-2

b. Commercial Application of the Inoculum

The inoculum for composting is consumed at the rate of 15 ltrs/day for treating 3 tones wastes in the Kurukkanpara plant in Kunnamkulam Municipality and only one-time application through spraying during the process of shredding, is sufficient. In the case of Kottappadi plant in Guruvayoor Municipality initial application is similar, but repeated application twice during turning of the compost pile is also prescribed taking into account the presence of more plantain leaves in the wastes. Gramapanchayaths like Eramala in Kozhikode, Puduppariyaram in Palakkad also use the inoculum in their plants. The two GPs function as spoke unit that avail the technical support CEWM.

BACIplus-2, the inoculum prescribed for activating biogas plants as partial substitute of cow dung is used in all the biogas projects undertaken by the PIU that covers institutional, community and household models. In the Medical College campus, Thiruvananthapuram, six biogas plants having a total feedstock capacity of 2600 Kg/day was activated using BACIplus-2.

Biogas plant at GMC, Thiruvananthapuram
Activated using BACIplus-2

c. Studies on compostability of fibre rich bio wastes

Biodegradation would be more effective when different biowastes are composted together. The reason is diversity of nutrients ensuring diversity of microbes in compost pile. Composition of wastes varies with culture and lifestyle of the people. In a temple township like Guruvayoor, wastes contain higher levels of plantain leaves and residues of fibre rich vegetables, which is difficult to degrade. In Kunnamkulam region chicken wastes are the dominant issue. The inoculum application in appropriate dosage could solve most of these issues that emerged in the recent past. CEWM recommend substrate specific dosage variation in inoculum application. Food and fruit wastes need to be mixed with vegetable wastes and composted together.

d. Studies on moisture absorbent additives

Moisture regulation is vital in aerobic composting. Moisture regulation of juicy vegetables and fruits is done by mixing dry coir pith, dried leaves, saw dust or their combinations. Shredded mushroom bed spent hay is not only a moisture absorbent, but it is also a fungal inoculum especially in degrading lignin and cellulose. Solid state pretreatment of raw coir pith using mushroom spawn is under investigation in CEWM. Semi digested compost also can be used as moisture absorbent material.

e. Composting of chicken slaughter wastes

Chicken waste composting method has been standardized by prescribing appropriate dosage of the inoculum developed in CEWM. A layer of chicken waste including the fur are spread on the floor on a one-inch thick coir pith-bed and the inoculum is sprayed on it, followed by another thin layer of coir pith. The process is repeated to a windrow height of 1.5 feet. The bed is once again sprayed with inoculum and fully covered with a thin layer of coir pith. Inoculum can be used at the rate of 5 or 6 L per ton of chicken waste depending on the intensity of smell. The quantity of coir pith would be roughly 200 kg per ton waste. Alternate moisture absorbents including partially composted wastes also can be used to reduce the quantity of coir pith. The compost pile may be turned in two weeks interval thrice by incorporating semi digested vegetable wastes and inoculum in case smell persists. The compost can be sieved after about 55- 60 days.

f. Studies on faecal sludge

Faecal sludge samples were collected from septic tanks and leach pits with the help of professional tank cleaners. The samples were subjected to chemical analysis and found that the material retains about 2 to 2.5% total organic matter and about half of that was volatile matter as reflected in the BOD. Desludging of faecal sludge cause microbial contamination and so it is a matter of concern.

Feacal sludge fed plant (Prototype model) in CEWM

Further studies conducted in the CEWM, showed that faecal sludge along with vegetable and food wastes can be fermented in biodigester to recover the carbon content as methane. The advantage is that the presence of sludge borne pathogens can be reduced to safe level. A prototype model of fixed dome ($0.5m^3$) biogas plant fabricated in IRTC workshop was used for the study. The experiment was repeated using $1m^3$ floating drum biogas plant having water seal. Biogas yield was about 190 litres per day. The outflow water coliform bacteria were within limits. The experiment used combined feedstock of faecal sludge and biowastes at the rate of 7.5 kg per day.

g. Studies on flood resilient toilets

Development of toilet linked digester models suitable for waterlogged areas are progressing. Options such as elevated toilets, single treatment system for combined organic wastes, biogas recovery to reduce sludge and ensure pathogen free release water are being considered. A work plan is ready on the design, fabrication and maintenance of flood resilient toilet linked Multi-feed Biogas Reactors based on preliminary studies.

3. TRAININGS

a. Training Facilities

Being an integrated technology Centre, IRTC has multidisciplinary facilities that attracts a host of trainees from different walks of life. In addition, it is also an official training Centre of the Kerala Institute of Local Administration. Consequently, there is a steady increase in the turnout of trainees especially in the recent past. During the last 3 years about 18,108 persons attended trainings in IRTC as per records, of which 9803 were in 2018-19. These include visitors and trainees from outside State, associated with All India Peoples Science Network. Located in picturesque landscape, the campus fascinates everybody and so campus visit is always a part of all trainings. Naturally the facilities reserved for waste management too are always in the limelight.

Training for LSG officials

b. Training in skill development

During the report period 3004 persons attended training in waste management as per records, of which 2275 were in 2018-19. Year wise split up is given below.

Trainees	2016-17	2017-18	2018-19	Total
Other States	25	Nil	20	45
Project Implementation Unit	33	40	50	123
Harithakarmasena	Nil	Nil	505	505
Farmers	25	Nil	60	85
KAU students	Nil	30	30	60
Kudumbasree workers	Nil	90	230	320
ATMA	Nil	Nil	290	290
SCERT	Nil	50	Nil	50
KSSP	Nil	30	170	200
Theeramythri	Nil	Nil	300	300
Peoples'Planning RP	Nil	Nil	380	380
LSG Elected Members	Nil	406	240	640
TOTAL	**80**	**646**	**2275**	**3004**

The turnout of trainees in this sector has been progressively increasing especially after the renovation of facilities under CEWM was completed. Obviously, it reflects the huge demand for practitioners in waste recycling technologies consequent to the Government initiatives in this field. Therefore, the turnout needs to be accelerated consciously, to deliver full utility of the facilities for skill development and capacity building in waste management technologies. The LSGD had given permission to the elected representatives and officials of LSGs to attend three days training in IRTC as per GO No 832/2017 dated 23-03-2017. Only 640 persons have so far attended the training. The training mode in this case was mostly demonstration and capability building in which skill development and learning by doing were meagre.

IRTC training sreies for LSGI members (Open hall)

KILA training series for Municipalities in IRTC (Smart class room)

Demonstration training for LSGI members (Kiosk)

Demonstration training for Municipalities (Vermi yard)

Demonstration training for LSGI members (Bio energy yard)

Demonstration training for LSGI (MRF)

c. Training for practitioners

Handholding trainings are essential for technology practitioners such as plant operators, plant supervisors, Harithakarmasena, Kudumbasree workers, MRF operators and JLG entrepreneurs. Hopefully, the LSGs might be able to direct a good number of them to IRTC for skill development, before deploying them for field work.

Jeevika team from Rohtas, Bihar in plant fabrication (Bio energy yard)

A group of 20 women who are members of JEEVIKA, an organization like KUDUMBASREE functioning in ROHTAS district, under DRDA, Government of Bihar, attended 24 days training (from 16-12-2018 to 08-01-2019) for learning the techniques of fabrication, charging, operation and maintenance of 2m^3 biogas plants.

The Green Energy Division of the Pondicherry University availed the services of the CEWM for establishing bio-energy units for strengthening their academic programmes and providing handholding trainings to PG students and teachers in in their campus. Government Engineering College, Kannur, is in academic collaboration with IRTC for using bioenergy yard facilities in CEWM. The Kerala Agricultural University also sent their UG and PG students for training in waste management as part of their Rural Agricultural Work Experience Programme. The Agricultural Technology Management Agency (ATMA) under the Agricultural Department avail training facilities in CEWM for demonstration and capacity building in bio-waste recycling. Kerala Institute of Local Administration also utilize the infrastructure in CEWM for demonstration training and capacity building in waste management.

d. Training modules and materials

Target group specific modules are used in the trainings offered from CEWM. Workers in non-degradable and degradable waste management at various levels come under this. Skill development trainings are mostly participatory in nature. The weightages for knowledge, skills and applications also vary accordingly. There is an expert team of facilitators in IRTC for regulating the training programmes.

A book entitled 'Science Technology in Practices: in Waste Management' authored by the HOD of the CEWM was published by KSSP. Two booklets, training modules and several articles on waste management were published during the report period. Apart from this several articles and audio visual presentation materials are also ready in the smart training hall maintained in IRTC.

Training in plastic segregation (Training Hall)

4. HUB AND SPOKE UNITS

Hub and spoke units in waste management sector are referred to the medium scale production units of bio gas or bio manure, that are operated by availing the handholding support of the Project Implementation Unit and CEWM jointly. Handholding support comprises of the facilitation services from PIU for enabling plant management, quality control, sale, finance management and ensuring inputs from the LSG concerned. The role of CEWM is to deliver continuous technical service support into the system such as inoculum supply for biogas plant activation as well as windrow compost acceleration, specifications of its application, protocol of operation, manure enrichment, biogas purification and use of end product. The plant management support involves formation of a Joint Liability Group of workers by fulfilling all formalities, formation of a Social Enterprise Initiative consisting of JLG, LSG and PIU and finally to run the system smoothly. The specific responsibilities of the LSG are to provide viability gap fund, door delivery of wastes at the plant and ensuring peoples support for sustaining the system.

Study team from California in compost yard at Kunnamkulam

Four spoke units are being operated under the above mention system for windrow composting. They are working at Kottappadi in Guruvayoor Municipality, Kurukkampara in Kunnamkulam Municipality, Eramala Gramapanchayath in Kozhikode and Puduppariyaram Grama Panchayath in Palakkad. The 3 tones/day windrow composting units established at Kurukkampara has been using IRTC inoculum since 2017. A series of experiments based on BACIplus-2 was conducted in windrow composting before the

Kiosk facility for training at Gramakala, IRTC

dosage of the inoculum was finalized. The inoculum was successfully used for composting chicken slaughter waste also, in the plant. The standardized protocol is practicing now to run the plant in social enterprise model by the JLG. The yield of the compost is remarkably high mainly because of the application of the inoculum by spraying at the time of shredding and moisture regulation using coir pith. Sieve rejects are recycled in the compost pile and hence about 90% recovery of bio-manure is attained.

The plant is a study Centre for IRTC training programmes in waste management for various stakeholders. The visiting team from California got fascinated by the plant operation and underwent practitioners training in the plant. It is understood that back home the members of the team started a similar plant in their country and is running well.

Such business model waste to wealth units can go a long way in promoting integrated farming systems. Latrine linked biogas plants established in Sinai Asramam, biopark established in Parassala Taluk hospital and a kiosk established in KILA campus, Mulankunnathukavu are other examples of technology dissemination from CEWM. The spoke units from biogas production are operated in the Govt. Medical Collge Thiruvananthapura. The 6 units two each in 200 kg, 500 kga and 600 kg capacities are functioning there since 2017. The biogas is being used for cooking.

5. TECHNICAL BACKUP IN DPR PREPARATION FOR LSGs

Preparation of DPR and its implementation are the tasks to be undertaken by IRTC/PIU for LSGs. DPR for integrated waste management requires several data inputs. Processed data is the basis for deciding treatment technology, size of equipment and machinery, construction of buildings, utility services, processing technology and plant management. The CEWM provides necessary technical backup for these activities.

The work during the last two financial years as per the records are briefed below.

In all 61 Grama Panchayaths have established a total of 94 plants for composting 100 tons waste per day at an investment of INR 251 lakhs. The projects were sponsored by 18 GPs and 13 BPs. Three Municipalities have constructed 6 composting plants at an investment of INR133 lakhs for treating a total of 50 tons waste per day.

Government Medical Colleges prefer biogas plants to compost plants. MC Kozhikode established 6 plants in 2011 for fermenting 6 tons waste per day. During the report period GMC, Thiruvanandapuram and two other Government Hospitals established biogas plants. Total installed capacity is 2600 Kg waste per day at an investment of INR 67 lakhs. Two MILMA Dairy plants have installed 100 kg biogas plants for treating food wastes. During the last two financial years 13 GPs have built 17 biogas plants for a total investment of INR 85 lakhs and for fermenting 3 tons waste per day.

The technical backup for waste treatment plants provided by CEWM is for a total quantity of 155 tons waste per day during the last two financial years. CEWM has also given technical backup for preparation of DPR for 1 LLD wastewater treatment plant at the Fishing Harbour Puthiyappa, Kozhikkode.

6. ALLIED ACTIVITIES

a. Information gathered from liquid waste treatment plants

The CEWM has enriched knowledge and information in the field of liquid waste management technology. A team of Research Advisory Committee members visited Greywater treatment plants, sewage treatment plants and septage treatment plants established in different locations in the state. Upward Anaerobic Sludge Blanket Reactor is found to be appropriate for the treatment of faecal sludge, after evaluating the performance of such a plant working at Brammapuram and owned by the Cochin Corporation. This technology is particularly suitable for homogenous liquid wastewater treatment such as dairy effluents as understood by the performance of such a plant at MILMA Kalpatta. MILA Palakkad is also installing a similar plant of 100 m^3 capacity through retrofitting into the existing STP.

Moving Bed Biofilm Reactor containing Submerged Anaerobic Fixed Film is suitable for sewage water treatment. A combination of aerobic and anaerobic MBBR ensure pathogen free treated water outflow. The RAC team could visit and study the treatment protocol of four such plants working in Thrissur and Ernakulam districts. Membrane Bio Reactors also perform well along with Reverse Osmosis assembly to purify greywater and enable reuse of treated water for many purposes. It is also understood from the study that the conventional treatment system for wastewater through activated sludge process can better be replaced by more efficient and less space demanding systems through retrofitting. The information so gathered were found to be useful in suggesting a solution to the faecal waste management issue in Karimkulam GP in Thiruvanandapuram. A DPR was submitted for introducing two sewage treatment plants having capacities 300m^3 and 500m^3 and sewerage connectivity to about 800 household latrines.

b. Information gathered from plastic recycling industries

The value chain of plastic rejects and e-wastes is very little understood by people. The hundred and odd plastic types belonging to 7 resin groups remains unfamiliar to most of the people. This knowledge gap is the main stumbling block for establishing a grass root system for segregation and channelizing. Why should people wash and dry plastic wastes before they are given to the refuse collectors who also collect green cess from them? A convincing answer to this question lies beyond the provisions of the Law and needs a preliminary understanding of the recycling technologies and its economy. Burning of plastic wastes might be their illegal permanent disposal

option whereas recycling is the option for safe recovery of material and energy from them. To realize this fact, exposure to recycling industrial units would be helpful. Such learning methods would de-school misconceptions on the use of shredders, extruders, pelletizers, grinders and bailing machines in MMRF. A single machine cannot serve its purpose on all types of plastic goods without getting itself damaged. Machine operation is very much end use specific, depending on the thickness and hardness of the material. CEWM staff assimilated such information through visits and studies from various plastic recycling industrial units. The benefit of this knowledge is reflected in the quality of trainings offered from CEWM.

c. Information gathered from indore municipal corporation and Madhukkara GP

Indore Municipal corporation was adjudged as the Neat City of India in 2016 and the award was bestowed on them in the 8th Regional 3R Forum in Asia and the Pacific Conference held at Indore, during 9th-12th December 2018. Indore is a litter free city because both biowastes and non-degradable wastes are stored at source, collected and removed to treatment plants regulated by a powerful management system well supported by the people. Indore is also a city free of stray animals. Bio wastes are recycled using aerobic windrow composting technology in 600 tons per day capacity plant and is being operated efficiently.

In addition, a biodigester having a capacity of 60 tones wastes per day is also functioning there. The biogas generated is purified by removing ammonia, hydregon sulphide and moisture. The pure biomethane is compressed and supplied in bottles as cooking fuel.

Madhukkara Grama Panchayath is a litter free local body near Coimbatore. At source, the wastes are segregated into vegetable and food wastes as well as plastics and sanitary wastes. They are stored separately and handed over daily to waste collectors. They are transported in three-cabin trucks to different destinations for processing. ACC cement factory Madhukkara collects all types of plastic wastes and put them into cement Kiln. Collection system is operated by an International company called Geocycle. About 100 tones wastes are collect daily. The maximum temperature in the furnace is 1800^0C that ensures complete oxidation of metals and non-metals. They are absorbed into the cement ingredients. High quality cement is manufactured here.

d. Information given from CEWM

The HOD of CEWM is a member of the State Level Advisory Body for Solid Waste Management as per GO (Rt) No. 140/2018/LSGD dated 16th January 2018. He is handling training classes for KILA regularly and a visiting faculty identified by KILA for subjects such as plastics and e-waste management, composting and bio fermentation technologies and liquid waste management. A retired teacher from Kerala Veterinary and Animal sciences University, he was offering courses in the bio wastes and environment related subjects for Academy of Climate Change Education and Re-

search as well as College of Forestry both under Kerala Agricultural University during 2013-2018 period. He has given several invited lectures for officers, teaching staff and doctors in Institutions such as College of Dairy Science and Technology, MILMA, Railway Colony Hospital, Palakkad, Medical Colleges and Universities including Pondichery university on subjects such as Plastic and e-waste management, methane recovery from dairy effluents, composting and fermentation technologies for bio waste management.

7. PATTERN OF FUND UTILIZATION

No.	Name	Total
1	Honorarium	21,48.751.00
2	One time Expenditure (Non-recurring)	37,07,407.00
3	Capital Expenditure	24,29,000.00
4	Recurring expenditure	19,05,512.00
5	R&D Activities	38,23,232.00
6	Travel	3,18,454.00
7	Institutional Overhead	7,27,043.00
	Total Expenditure	**1,50,59,399.00**
	Special grant assistance from Government	**1,50,00,000.00**

8. ACADEMIC BACKUP

The CEWM has availed Research Advisory Support, Senior Faculty Support and Research Staff Support during the report period. Excluding the research staff who left IRTC all other experts mentioned above continue to guide the activities of CEWM.

a. Research Staff

1. Prof. V.R. Raghunandanan, HOD, Centre of Excellence in Waste Management (CEWM)
2. Smt. V.Susmitha, MSc, Microbiology
3. Fathima Nashwa, Msc, Microbiology
4. Preetha Mol, MSc, Microbiology (2014-16)
5. Divya, BSc, Chemistry (2016-18)
6. Maria Midhu Francis, MSc, Chemistry (2018-19)

b. Research Advisory Support

1. Dr. D. Girija, Professor in Microbiology, KAU
2. Dr. P. Sureshkumar, Professor, Radio Tracer & Soil Chemistry, KAU
3. Dr. P. Jayaprakash, HOD, Electrical and Electronic Department, Govt. Engineering College, Kannur
4. Er. Suresh Narayanan, Senior Faculty, IRTC
5. Er. T.C. Subran, Consultant, Liquid Waste Management.
6. Er. P Sandeep, Consultant, Liquid Waste Management.
7. Er. M. Dileepkumar, Consultant, Liquid Waste Management

c. Senior Faculty, IRTC

1. Dr. M.P. Parameswaran, Senior Fellow
2. Dr. S. Sreekumar, Director, IRTC
3. Sri. K.K. Janardhanan Registrar IRTC
4. Dr. M. Balagopalan, Director of Research, IRTC
5. Dr. N.K.Sasidharan Pillai, Former Director, IRTC
6. Prof. P.K. Ravindran, Former Director, IRTC
7. Prof. B.M. Musthafa, Head, Energy Division
8. Sri. R. Satheesh, Head, Natural Resource Management Division
9. Sri. V.G. Gopinathan, Former Registrar, IRTC
10. Sri. Sreesankar T.P., Executive Director, Parishad Production Centre
11. Sri. P.V. Joseph, Secretary, Parishad Production Centre
12. Sri. A.K. Mathew, Secretary, Project Implementation Unit

9. AWARD RECEIVED

IRTC was the recipient of the 3R Excellence Award for Civil Society Organizations for 2018. A certificate of appreciation for exemplary work in the area of waste management through 3R (Reduce, Reuse and Recycle) was awarded in a function of the 8th 3R Forum in Asia and Pacific, held at Indore during 9-12 April 2018.

Integrated Rural Technology Centre (IRTC)

Mundur, Palakkad, Kerala-678592

Centre of Excellence in Waste Management

IRTC

Grant-in-aid Institution of KSCSTE
Govt. of Kerala

www.irtc.org.in

mail@irtc.org.in

Mundur, Palakkad-678592