INTERNSHIP PROJECT WITH THE KERALA STATE PLANNING BOARD

EVALUATING TECHNOLOGICAL OPTIONS FOR MUNICIPAL SOLID WASTE MANAGEMENT IN THIRUVANANTHAPURAM CITY

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1 INTRODUCTION

Rapidly expanding populations exert enormous pressure on natural and infrastructural resources in urban spaces. Coupled with the increasingly consumerist nature of urban living, these populations have the notorious capacity to trigger a breakdown of their own civic structures, institutions and systems. A most singular example is the state of urban solid waste management and the resulting socio-economic, environmental and public health issues that emanate from its utter neglect. This is a challenge that afflicts cities around the world, particularly in developing countries such as India.

Municipal Solid Waste Management (henceforth MSWM or SWM) refers to the planning, financing, construction and operation of facilities required for the collection, handling, transport, treatment, resource recovery from and disposal of solid waste in cities by the local municipal authorities. (Annepu, 2012) The emphasis is on managing waste in a decentralized manner. Centralized control and delivery of SWM services is inappropriate for the simple reason that the characteristics of waste such as composition and quantity vary significantly between regions. Concomitantly, extremely localized management of waste has traditionally been considered unfeasible. This is ostensibly due to the fact that waste handling, recovery and disposal requires the provision of resources that cannot be furnished individually to every single household or locality. Therefore, the delivery of SWM services must primarily be the responsibility of urban local governments. On the other hand, central and state governments need to play their part by laying down objectives and designing policies for SWM. (CPHEEO, 2005)

In light of these recommendations, recent legislation regarding SWM in India has clearly spelled out the roles of various stakeholders (viz, government institutions), in line with the nation's federal administrative structure. The Ministry of Environment, Forest and Climate Change, along with the Ministry of Urban Development, is responsible for framing general policies, issuing guidelines and aiding the local governments in training and capacity building towards sustainable SWM practices.

The Ministry of Chemicals and Fertilizers, along with the Ministry of Agriculture, is charged with the framing of policies for and promoting the use of compost. The Ministry of New and Renewable Energy Sources, along with the Ministry of Power, must supervise the installation, operation and proliferation of waste-to-energy plants. In addition to these ministries, the Central Pollution Control Board is accountable for formulating specific technical standards in line with the best global practices, publishing and timely reviewing of guidelines and co-ordinating the activities of the various State Pollution Control Boards. The State Pollution Control Boards in turn are responsible for monitoring the adherence to these standards and guidelines by the local bodies, issuing, renewing or suspending authorisation to local bodies for waste treatment facilities and regulating inter-state movement of waste. Finally, the local governments (Municipal Corporations, Municipalities and Panchayats) are responsible for preparing a SWM plan, arranging for door-to-door collection, framing bye-laws, handling and transporting solid waste (especially non-biodegradable waste), setting-up solid waste processing facilities, preparing annual reports etc. (MoEF & CC, 2016) In summation, this streamlined flow of authority and liability from the highest tier of government to the lowest is a major step towards ensuring that people and institutions do not shirk responsibility as they can now be held accountable not only for their actions but also for plain inaction.

In recent times though, the development of SWM technologies have opened up avenues for further decentralization of waste processing. Especially fruitful has been the development of composting (for aerobic reduction of waste) and biogas plants (for anaerobic reduction of waste). These can now be performed at much smaller scales than was possible a few decades ago; individual households and small establishments are in fact the key market for manufacturers of biogas plants. The possibility of ultimate decentralization i.e. waste processing at source, necessitates a shift in outlook for the urban local bodies – from blindly handling and processing urban waste, to encouraging individual households and establishments to do so themselves.

Thiruvananthapuram, the capital city of Kerala, was historically considered to be one of the cleanest cities in the country. The city has since lost its sheen to rapid urbanization, lack of foresight, mismanagement and under-involvement of the larger populace in matters of waste disposal. The study aims to highlight the various issues pertaining to SWM in Thiruvananthapuram Municipal Corporation.

More precisely, the objectives of this study are:

- To appraise, in the milieu of Thiruvananthapuram city, the stance taken by the Kerala State Pollution Control Board to convert all open dumpsites into sanitary landfills.

- To compare the district wise performance of the biogas subsidization scheme and review the usage of biogas plants in Thiruvananthapuram city.

The paper is organised into 7 sections. Section 2 delves into the various technological options available for SWM. Section 3 discusses the administrative and legal framework regarding SWM in India. Section 4 provides a review of the relevant literature and takes a look at SWM scenario at various levels of aggregation – global, national, state and city. Section 5 describes the methodology used for the research. Section 6 then goes into a detailed discussion of the situation of biogas technology and an analysis of primary and secondary data. Section 7 winds up the arguments with the conclusion and policy recommendations.

2 TECHNOLOGICAL OPTIONS FOR SOLID WASTE MANAGEMENT

There is a wide range of technological options available for the processing, treatment and disposal of municipal solid waste. Six key technologies are elaborated here:

2.1 Composting (Aerobic Reduction)

Composting is the controlled decomposition of organic matter through biological processes, resulting in nutrient-rich humus. In Vermicomposting, this biological process is performed by specially reared worms. This method has been in use in India since a long time.

- Merits – Simple and straightforward (if waste is source-separated); limited capital investment; can be done at any scale

- Demerits – Only for organic waste; high land requirement; open composts are hampered during monsoons by rain, rodents and flies; untapped methane emissions are a problem

2.2 Biomethanation (Anaerobic Reduction)

These involve the use of 'biogas plants'. This technology has the dual advantage of waste disposal and recovery of resources from it, in the form of biogas and highly fertile compost. This method has also been widely used in India.

- Merits – Ideal for (tropical/sub-tropical) Indian conditions; plants are easy to operate and maintain; suitable for wet waste which cannot be composted; net energy producing process; can be done at small scale; free from odour, rodent/fly menace

- Demerits – Only for simple organic waste; waste-water often needs to be treated to meet statutory standards; biogas leakage is a potential environmental and fire hazard

2.3 Incineration

Incineration refers to the complete combustion of waste materials. Since physical matter cannot be destroyed, an incinerator actually transforms the original waste materials into several new materials including air emissions, ash and liquid discharge. It is used commonly in developed countries that experience paucity of land, or where the waste has a high calorific value. For harder biomass that does not decompose easily (such as coconut shells), one can perform Bio-incineration using biogas.

- Merits – Can decrease waste volumes by up to 90 %; continuous feed and high throughput possible; thermal energy recovery for direct heating or power generation; relatively noiseless, odourless; low land area requirement; hygienic

- Demerits – Unsuitable for waste with high moisture or inert content; high capital, operation and maintenance costs; skilled labour required for operation; emissions are a huge concern

2.4 Pelletisation (Refuse Derived Fuel)

Solid waste is reduced in bulk by compression or extrusion to form briquettes which can then be used as fuel in incinerators or industries. Binding agents are added in the process to make the briquette resistant to moisture damage and increase its calorific value.

- Merits – RDF pellets are easy to store and transport; can effectively take care of imbalances in the input waste feed to power plant

- Demerits – RDF pellets are useless until a dedicated power plant is constructed to utilize them; energy intensive; unsuitable for waste with high moisture content; distinct possibility of toxic contamination

2.5 Pyrolysis/Plasma Gasification

These are thermal processes that use high temperatures to break down waste and produce fuel gas and fuel oil. Unlike incineration though, very little oxygen is used and thus combustion is incomplete.

- Merits – Fuel gas/fuel oil is an alternate for fossil fuels; lack of oxygen means no possibility of harmful nitrous and sulphurous oxides; attractive for disposal of hazardous waste

- Demerits – Capital intensive; unsuitable for waste with high moisture and inert content; fuel oil is highly viscous making it difficult to transport and burn.

2.6 Sanitary Landfilling

A sanitary landfill is an area onto (or into) which waste is deposited in a way that restricts contact between the waste and the surrounding environment, particularly the groundwater. Most supposed sanitary landfills in the developing world are actually mere open dumps or semi-controlled landfills.

- Merits – Natural resources are returned to the soil and recycled; relatively low cost; landfill gas if tapped can be used for power generation or as domestic fuel; skilled labour not required for operation

- Demerits – Down-gradient surface water may be polluted with surface run-off resulting in 'leachate' that contains concentrated toxic chemicals and is ecologically hazardous; underground aquifers may get polluted; inefficient gas recovery process which may ultimately be a potential environmental and fire hazard; large land requirement; cost of transporting waste to landfill site is often high

An urban local planner or body must choose the appropriate technology mix after considering several factors, namely:

- Site specific circumstances (geographic, socio-economic considerations)
- Quantity of waste
- Quality/composition of waste
- Presence of hazardous/toxic matter in the waste
- Availability of outlets for energy produced
- Market for compost and biomethanation sludge
- Grid power prices
- Cost of alternatives
- Capital, land and labour costs
- Health of public and refuse workers
- Cost of implementing safeguards against environment pollution

3 LEGAL FRAMEWORK

MSWM initiatives by the government were started in the 1960s when soft loans were made to local bodies for promoting composting of urban solid waste. The fourth five year plan (1969-74) earmarked separate funds to provide grants and loans to state governments for setting up composting facilities. In 1975 the government constituted the first high powered committee for a holistic review of MSWM problems. Another committee was setup in the aftermath of the bubonic plague of Surat in 1994. In 1995 the Ministry of Health and Family Welfare undertook a national mission on sanitation and environmental health and the Ministry of Urban Development drafted a policy paper. These developments led to the setting up of more than 35 composting facilities with private sector participation across the country during the period 1995-2000.

A pilot programme to promote waste-to-energy projects was initiated by the Ministry of Non-Conventional Energy Sources in 1996. It was around this period that the role of Non-governmental organisations and Community-based organisations in MSWM found wider acceptability and greater significance, and the number of PILs filed increased manifold. Another committee constituted in 1998 tabled its report a year later, giving wide-ranging recommendations on improving waste management systems, right from storage to disposal and covering institutional, financial, legal and health aspects.

The first consolidated and comprehensive set of rules laid down to tackle MSWM in India were the draft rules of 1999, which were then finalized as the Municipal Solid Waste (Management and Handling) Rules, 2000 issued by the Ministry of Environment and Forests. The notification clearly demarcates the statutory norms for collection, segregation, processing and disposal of waste including standards for compost quality, leachate control and management and control of landfill sites. It emphasises the role of urban local bodies in carrying out the day-to-day management and disposal of waste in conformance with these rules, and that of the State Pollution Control Boards and State Government in regulating and ensuring proper implementation of these rules. The initial time frame given to urban local bodies to improve waste management systems as envisaged in the rules was until 2003 year end. For the most part, however, the rules remain only on paper. Indeed, urban local bodies are grappling with their waste even 16 years after the rules were promulgated.

With regards to choice of technology used for waste processing and disposal, Schedule II of the rules, which pertains to management of municipal waste, states that “Municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill”. For example, it states “biodegradable wastes shall be processed by some biological processing for stabilization of waste.....Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing.” (MoEF, 2000)

The next major legislation was drafted more recently in 2015, and promulgated as the Solid Waste Management Rules, 2016. New additions involve rules regarding segregation at source, collect back systems for packaging waste, user fees collection, marketing and promotion of compost and waste-to-energy, and collection and disposal of sanitary waste. The remainder of the directive is mostly an extension of the earlier rules and is a step towards further streamlining and standardising MSWM. The 2016 rules take a similar stance with regard to the use of various technologies. Biodegradable waste must be processed, treated and disposed of through composting or biomethanation within the premises as far as possible and the residual waste shall be given to the waste collectors or agency as directed by the local authority. Additionally, the rules suggest that individual landfills for localities and smaller towns may be a less viable option than 'regional' landfills that have a larger capacity and cater to multiple localities. For census towns with a population below 1 million or for all local bodies having a population of 0.5 million or more, common, or stand-alone sanitary landfills will have to be set up in three years time. (MoEF & CC, 2016)

In Kerala, the State Pollution Control Board has asked all urban local bodies “to modify all existing open garbage dumps into sanitary landfills”, as seen on its website. Moreover, where no such site was available, the local body has been directed to earmark an area in consultation with the Development Authority.

4 REVIEW OF LITERATURE – SWM IN CONTEMPORARY TIMES

4.1 World

The best estimate of a global municipal solid waste generation rate is around 2 billion tonnes per annum. (UNDP, 2015) National generation rates, though widely varying, have a strong positive correlation with national income. Yet, it is the low and middle income countries that are showing phenomenal growth in their waste generation rates.

It is these very developing countries that find themselves ill-equipped to handle large and increasing quantities of urban waste. In the face of more pressing economic and developmental imperatives, waste management and sanitation often take the back seat. It is estimated that at least 2 billion people worldwide still lack access to solid waste collection and at least 3 billion people worldwide still lack access to controlled waste disposal facilities. (UNDP, 2015) This has led to deterioration of living conditions and of overall public health in developing countries, especially in urban areas. Organics comprise a larger fraction of the waste in developing countries – typically 50% to 70% – as compared to the 20% to 40% for high income countries. (UNDP, 2015) In contrast, the proportion of paper and plastic in waste is greater for high income countries. Implicatively, a one-size-fits-all strategy for MSWM is bound to fail.

4.2 India

The SWM scenario in urban India is a quintessential example of that in developing countries. Between 1991 and 2011, the annual municipal solid waste generated in urban India increased from 23.86 million tons to more than 68.8 million tons. It is projected to reach 260 million tons by the year 2047. (Singhal et. al., 2000) With the increase in waste, methane emissions from dump yards have also increased from 119 kilo-tonnes in 1980 to 400 kilo-tonnes in 1991. (Kumar et. al., 2004) As urban populations expanded rapidly and waste generation rates increased by an even greater factor, infrastructural resources such as MSWM facilities have been put under immense pressure, subsequently causing deterioration.

As SWM is of local nature it is the responsibility of the State which in turn has entrusted it to local authorities who carry out the solid waste management in areas under their control using mostly their own funds, staff and equipment. The urban local bodies spend approximately Rs.500 - Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on collection, 20-30% on transportation and less than 5% on processing and final disposal. (Visvanathan et. al. 2004)

The organic fraction of waste is typically very high in India (40-50%). However, increasing incomes have led to lowering of organic content and increase in 'luxury' component including cardboard, plastic, paper, etc. making processing, treatment and disposal less manageable. (Ahmed & Jamwal, 2000)

When surveyed in 2004, compliance rates to MSW (M&H) Rules, 2000 were extremely low on all fronts: 53% for transporting waste, 42% for storage at source, 39% for primary collection, 37% for segregation of recyclables and a paltry 9% for waste processing and 1% for disposal/landfilling. (Asnani, 2006)

According to a report published by the Government of India on the National Implementation Plan for Persistent Organic Pollutants (PoPs) in 2011, 94% of the total municipal solid waste generated is still dumped openly, 4% is composted and only 2% recycled. (Government of India, 2011)

4.3 Kerala

Rapid urbanization, constant change in consumption pattern and social behaviour have increased the generation of municipal solid waste in Kerala beyond the assimilative capacity of our environment and management capacity of the existing waste management systems. Waste generation in the municipalities of Kerala state is estimated to be upwards of 0.21 kg/capita/day. (Varma, year unknown)

It is also pertinent to note that from 2001 to 2011, the number of 'towns' (as defined by the Census) in Kerala increased 5-fold, although many of these do not have statutory local governments. Though all 5 Municipal Corporations have waste processing plants, as of 2013 only 27 of the 60 Municipalities had any such facility. (Ahluwalia & Tiwari, 2013) This is, to some extent, an indicator of the paucity of land and high density of population in the state.

Situated fairly close to the equator, Kerala's hot tropical climate is an excellent environment for anaerobic decomposition of waste, both thermal and biological. Aerobic decomposition (composting) may be hampered at times by the high moisture content in the air. This is fostered also by the large share of biodegradables in Kerala's waste – over 70% as compared to less than 50% for the rest of India (Ahluwalia & Tiwari, 2013).

The SWM Rules, 2015 suggest that regional landfills might be better than individual landfills for individual areas. This view is supported by studies conducted by Suchitwa Mission, the state's nodal agency for sanitation. Additionally, the waste that arrives at such dump yards is unsegregated and often more than its capacity; landfills would thus overflow with all kinds of waste, some of which could have been processed biologically.

4.4 Thiruvananthapuram

A few studies have delved into the identification of the types and estimated the quantities of waste generated in each ward of Thiruvananthapuram City Corporation. It has been estimated that a total of 290-300 tons of solid waste is generated in the city every day. The recyclable portion of this waste is sold to the wholesale dealers and transported to Salem and Coimbatore for recycling. (Ambat, 2000)

Lack of space and practice are considered to be the main reasons why wastes are not segregated and thrown on the road side. People are not willing to do any segregation of waste except the newspapers. Majority of the hospitals dump the waste in the dumper placer containers or burn it in the hospital premises. About 55% of the households follow the practice of reducing, reusing and recycling the waste materials. Majority of the low-income and middle income houses burn 60% of the waste generated and sell the rest for a nominal rate. 88% of the people feel that they have a role to play in solid waste management, showing the change in the attitude of the people towards solid waste management. People prefer a door to door collection system and were willing to pay for an improved service of solid waste collection. (Ambat, 2000)

Thiruvananthapuram city's experience with community-scale composting and subsequent landfilling is an exemplar on how well intentioned MSWM initiatives may go awry if not planned properly. The Vilappilasala Composting plant started off as an extremely promising project, with construction beginning in December 1999. Initial opposition from locals was thwarted by arranging a tour for senior Panchayat officials to a similar plant in Vijayawada, Andhra Pradesh, which had them convinced. The composting factory was designed for a capacity of 1.5 to 1.6 tons. However, almost all of the city's waste – approximately 300 tons – was sent to the plant right from the initial days. Over time, the excess waste piled up in the area. This caused several major issues:

- Composting plant efficiency fell drastically and quantity of rejects increased with time, as big heaps would block air flow and not permit aerobic composting to occur correctly.

- Rain water mixed with the waste and flowed into a nearby stream to finally meet the

Karamana river. The leachate had contaminated both drinking water supply and underground water, as proven by independent environmental studies. (Anju Anilkumar et. al., 2015) and by spot enquiries conducted by the State Pollution Control Board.

- Air pollution caused serious repercussions on public health in Vilappilasala. The number of respiratory illnesses shot up drastically once the plant was operationalized. (Shyjan & Mohan, 2013)

- Bad odour and insect vectors were wreaking havoc in the surrounding areas

In addition, some of the residential areas on the coast were as far as 30 to 40 km away from the plant site. This led to the dual challenge of maintaining safety standards in transporting waste long distances and managing enormous fuel expenses. The project was finally shelved due to public outcry emanating from these reasons. What was initially planned as a sanitary landfill finally ended up as an open dump yard, capped at 6 lakh tons of municipal waste and rejects from the treatment plant.

This experience highlights the unsustainable and uneconomical nature of centralized MSWM as it is practised in the country. Community scale waste treatment plants must be limited to the processing of non-biodegradable waste and rejects from the biogas plants of individual households. The ideal solution, vetted by the current legislation, is to handle and treat as much waste at source as is possible. In this regard, biogas plants are an extremely viable solution, more so in India (and even more so in Kerala), where the organic fraction of waste is high. Subsidies for biogas plants, technical support and standardization of the plants, awareness and training campaigns are some of the alternatives that government authorities have undertaken in this regard; there is, however, much scope for progress.

5 METHODOLOGY

The study makes use of both deductive and inductive modes of reasoning to establish arguments. To review of the district wise performance of the biogas subsidization scheme, a quantitative analysis of the list of subsidy beneficiaries was performed. This secondary dataset was provided by the Agency for Non-Conventional Energy and Rural Technology (ANERT), Thiruvananthapuram. The data spans four consecutive years, starting 2011-12, and is thus fairly comprehensive in capturing trends and anomalies.

To study the performance of biogas plants amongst households in Thiruvananthapuram city a primary survey was conducted. The first step involved making a comprehensive list of subsidy beneficiaries in the city. Initially, a sizeable number of interviewees were chosen from this list. However, due to a number of issues including locked houses, lack of willingness to be interviewed, language barrier and on logistic grounds, the final number of survey participants was limited to 20. This included households and institutions spread over Sasthamangalam, Vellayambalam, Kowdiar, Medical College and other areas. The interviews were based on a structured questionnaire with the objective of recording the experiences of the users of biogas technology. The questionnaire for institutions was appropriately modified. This data could then be qualitatively studied to gain an understanding of the underlying reasons, opinions, and motivations for using biogas.

In addition to this, in-depth interviews were conducted with SWM experts in the city. The objective of these interviews was to gain insights into the market for decentralized SWM services and to understand what further policies would be required to strengthen this market.

6 DISCUSSION & ANALYSIS

The Central government has been operating the National Biogas and Manure Management Programme (NBMMP) since 1981, essentially for subsidizing family type biogas plant. NBMMP also provides for five years free maintenance warranty; financial support for repair of old non-functional plants; training of users, staff, entrepreneurs, etc. and publicity and communication. The amount of subsidy released for general category states, including Kerala, was in the range of Rs. 9000 – Rs. 4000 per unit earlier and has now been increased to Rs. 11000 – Rs. 9000.

The programme is being implemented by State Nodal Agencies (SNAs)/State Nodal Departments (SNDs) like Agriculture Department, District Rural Development Agencies (DRDAs) and Khadi and Village Industry Commission (KVIC) centres. The main objectives of the scheme are to provide clean bio-gaseous fuel mainly for cooking purposes; for reducing use of Liquefied Petroleum Gas (LPG) and other conventional fuels; and to provide bio-fertilizer/organic manure to reduce use of chemical fertilizers. (Union Civil Performance Renewable Energy Report, 2015)

The Kerala state government has implemented another scheme on the same lines, the subsidy for which ranged from Rs. 16000 – Rs. 8000 depending on the size of the plant, in the year 2011-12. Subsequently, this amount has been fixed at Rs. 8000 for all plants. The nodal agency in the state for handling subsidy disbursement and evaluation of the plants for both the Central and State schemes is ANERT.

Using the subsidy beneficiary lists for four years that were made available by ANERT, the annual number of subsidized plants installed (for every subsidy denomination) and total annual amount of subsidy disbursed was calculated for each district for the four years, separately for both the Central and State schemes. Using data for number of households (Department of Economics & Statistics,

2013) and assuming that these numbers would not show drastic alterations across the four years, a measure of district-wise utilization of subsidy, Subsidy Utilization Index (SUI), was computed for all the districts. SUI is calculated as the total subsidy disbursed per household. The data is presented Tables 1 to 4.

It is clear from the data that Thiruvananthapuram is by far the worst performer of all the 14 districts in terms of subsidy utilization – it has the lowest SUI in three out of four years, way below the state average. This information is to be digested along with the fact that Thiruvananthapuram is the largest district in terms of number of households. Malappuram, Kannur and Kollam are the other laggard districts, although with better numbers. On the other hand, Idukki, Wayanad and Kottayam districts have consistently high SUIs, higher than Thiruvananthapuram district by an order of magnitude.

Table 1: District-wise Subsidy Disbursement Data (2011-12)

No.	**District**	**No. of subsidized biogas units installed**									**Subsidy Amount(Rs.)**			**No. of Households (in lakhs)**	**SUI**
		State Subsidy				**Central Subsidy**					**State Subsidy**	**Central Subsidy**	**Total**		
		16000	**12000**	**8000**	**Total**	**9000**	**8000**	**5000**	**4000**	**Total**					
1	Idukki	0	0	241	241	0	24	0	0	24	1928000	192000	2120000	2.8	7.57
2	Wayanad	24	1	73	98	0	28	0	2	30	980000	232000	1212000	1.91	6.35
3	Kottayam	0	0	304	304	6	34	0	4	44	2432000	342000	2774000	4.87	5.70
4	Ernakulam	29	18	318	365	1	101	0	7	109	3224000	845000	4069000	8.14	5.00
5	Alappuzha	10	81	142	233	0	7	0	37	44	2268000	204000	2472000	5.36	4.61
6	Kasargode	0	0	106	106	0	17	0	11	28	848000	180000	1028000	2.73	3.77
7	Kozhikode	35	17	159	211	3	44	0	10	57	2036000	419000	2455000	6.98	3.52
8	Pathanamthitta	7	4	97	108	0	22	0	1	23	936000	180000	1116000	3.23	3.46
9	Thrissur	31	4	133	168	1	66	1	9	77	1608000	578000	2186000	7.59	2.88
10	Palakkad	32	18	100	150	1	19	0	5	25	1528000	181000	1709000	6.37	2.68
11	Kannur	7	40	87	134	0	8	0	3	11	1288000	76000	1364000	5.54	2.46
12	Malappuram	0	0	163	163	0	23	0	1	24	1304000	188000	1492000	7.94	1.88
13	Kollam	0	0	108	108	0	26	0	4	30	864000	224000	1088000	6.69	1.63
14	Thiruvananthapuram	0	0	111	111	1	15	2	6	24	888000	163000	1051000	8.38	1.25
	Kerala	175	183	2142	2500	13	434	3	100	550	22132000	4004000	26136000	78.53	3.33

Sources: ANERT, Department of Economics & Statistics and Author's computations

Arranged in decreasing order of SUI

Table 2: District-wise Subsidy Disbursement Data (2012-13)

No.	District	No. of subsidized biogas units installed				Subsidy Amount (Rs.)			No. of Households (in lakhs)	SUI
		State Subsidy	Central Subsidy			State Subsidy	Central Subsidy	Total		
		Total (All 8000)	8000	4000	Total					
1	Alappuzha	678	21	94	115	5424000	544000	5968000	5.36	11.13
2	Idukki	103	137	3	140	824000	1108000	1932000	2.8	6.90
3	Kottayam	335	72	1	73	2680000	580000	3260000	4.87	6.69
4	Wayanad	59	81	2	83	472000	656000	1128000	1.91	5.91
5	Kozhikode	385	100	23	123	3080000	892000	3972000	6.98	5.69
6	Thrissur	209	223	4	227	1672000	1800000	3472000	7.59	4.57
7	Ernakulam	280	163	19	182	2240000	1380000	3620000	8.14	4.45
8	Pathanamthitta	138	20	4	24	1104000	176000	1280000	3.23	3.96
9	Kannur	187	8	39	47	1496000	220000	1716000	5.54	3.10
10	Palakkad	100	124	18	142	800000	1064000	1864000	6.37	2.93
11	Malappuram	166	24	0	24	1328000	192000	1520000	7.94	1.91
12	Kollam	58	28	0	28	464000	224000	688000	6.69	1.03
13	Thiruvananthapuram	50	35	0	35	400000	280000	680000	8.38	0.81
14	Kasaragod	25	1	0	1	200000	8000	208000	2.73	0.76
	Kerala	2773	1037	207	1244	22184000	9124000	31308000	78.53	3.99

Sources: ANERT, Department of Economics & Statistics and Author's computations

Arranged in decreasing order of SUI

Table 3: District-wise Subsidy Disbursement Data (2013-14)

No.	District	No. of subsidized biogas units installed					Subsidy Amount (Rs.)			No. of Households (in lakhs)	SUI
		State Subsidy	Central Subsidy				State Subsidy	Central Subsidy	Total		
		Total (All 8000)	9000	8000	4000	Total					
1	Alappuzha	653	0	16	7	23	5224000	156000	5380000	5.36	10.04
2	Wayanad	19	1	99	0	100	152000	801000	953000	1.91	4.99
3	Thrissur	168	17	215	2	234	1344000	1881000	3225000	7.59	4.25
4	Ernakulam	175	0	241	6	247	1400000	1952000	3352000	8.14	4.12
5	Idukki	9	1	114	0	115	72000	921000	993000	2.8	3.55
6	Kottayam	76	8	71	0	79	608000	640000	1248000	4.87	2.56
7	Kozhikode	35	0	115	0	115	280000	920000	1200000	6.98	1.72
8	Pathanamthitta	48	0	10	0	10	384000	80000	464000	3.23	1.44
9	Palakkad	14	0	62	3	65	112000	508000	620000	6.37	0.97
10	Kollam	29	0	27	0	27	232000	216000	448000	6.69	0.67
11	Malappuram	13	0	37	0	37	104000	296000	400000	7.94	0.50
12	Kasaragod	0	0	11	0	11	0	88000	88000	2.73	0.32
13	Kannur	1	0	9	0	9	8000	72000	80000	5.54	0.14
14	Thiruvananthapuram	4	0	9	0	9	32000	72000	104000	8.38	0.12
	Kerala	1244	27	1036	18	1081	9920000	8603000	18555000	78.53	2.36

Sources: ANERT, Department of Economics & Statistics and Author's computations

Arranged in decreasing order of SUI

Table 4: District-wise Subsidy Disbursement Data (2014-15)

No.	District	No. of subsidized biogas units installed					Subsidy Amount (Rs.)			No. of Households (in lakhs)	SUI
		State Subsidy	Central Subsidy				State Subsidy	Central Subsidy	Total		
		Total (All 8000)	11000	10200	9000	Total					
1	Idukki	270	2	2	251	255	2160000	2485000	4645000	2.8	16.59
2	Kottayam	326	0	14	112	126	2608000	2436000	5044000	4.87	10.36
3	Wayanad	67	7	0	86	93	536000	851000	1387000	1.91	7.26
4	Pathanamthitta	219	0	0	22	22	1752000	198000	1950000	3.23	6.04
5	Thrissur	167	0	11	136	147	1336000	2346000	3682000	7.59	4.85
6	Alappuzha	301	0	0	20	20	2408000	180000	2588000	5.36	4.83
7	Ernakulam	248	0	0	123	123	1984000	1107000	3091000	8.14	3.80
8	Palakkad	89	1	9	49	59	712000	1370000	2082000	6.37	3.27
9	Kasaragod	61	0	0	41	41	488000	369000	857000	2.73	3.14
10	Kannur	144	0	0	47	47	1152000	423000	1575000	5.54	2.84
11	Kollam	187	0	0	7	7	1496000	63000	1559000	6.69	2.33
12	Malappuram	188	1	1	21	23	1504000	302000	1806000	7.94	2.27
13	Kozhikode	89	1	0	63	64	712000	578000	1290000	6.98	1.85
14	Thiruvananthapuram	103	1	0	12	13	824000	119000	943000	8.38	1.13
	Kerala	2459	13	37	990	1040	19672000	12827000	32499000	78.53	4.14

Sources: ANERT, Department of Economics & Statistics and Author's computations

Arranged in decreasing order of SUI

The questionnaire for the primary survey is presented in the Appendix. The key findings from the survey are as follows:

- 13 of the 20 plants were still functional.
- Most head of households themselves initiated the process of considering whether to install a biogas plant; they were beneficiaries in all the cases.
- All participants installed the plant to save on domestic fuel consumption.
- For all the households, the mode of waste disposal prior to the biogas plant was open dumping, accomplished by employing the services of waste pickers for Rs. 50 – Rs. 100 a month.
- All participants became aware of biogas technology either through newspaper advertisements or by word-of-mouth.
- Participants were apprised of the government subsidy scheme (all knew of only one scheme's existence) by their biogas plant turnkey agent.
- Daily biogas output varied from 20 minutes to 90 minutes depending on the type and quantity of waste input.
- All compost output went into the trees/plants around the household. No participant knew of any mechanism or market to sell this product in.
- Regular checks were not performed on the non-functional biogas plants.
- Out of the 13 functional plants, owners of 11 plants were fairly satisfied with the plant's performance and the turnkey provider's service.
- One commonly occurring problem in the plant was the tube getting blocked with sludge.

7 CONCLUSION & RECOMMENDATIONS

Out of the 73 cities across the country that were assessed for cleanliness as a part of the Swachh Survekshan project under the Swachh Bharat Abhiyaan, Thiruvananthapuram ranked 40. (MoUD, 2016) Open dumping is the order of the day in the city and no centralized community-level waste processing or treatment plant exists at the time being, except for small scale incineration units that are unhealthy for the ecosystem.

Given the vast array of technologies and social arrangements available for MSWM, the stance taken by the Kerala State Pollution Control Board (as seen in the directives on its website) of converting all open dumps into sanitary landfills is not an ideal strategy. To convert any open dump into a sanitary landfill would involve transporting the waste to another area and constructing the landfill from scratch. With the large number of open dumping areas in the city, this would be a Sisyphean task as cleaning up one dump would imply overloading another in the interim; this is over and above the logistical and financial nightmare that such an exercise would prove to be.

Since the very inception of biogas technology and programmes, Kerala has seen greater proliferation of family type biogas plants than many other states. (CPHEEO, 2005) Yet, Thiruvananthapuram district appears to be an extreme outlier in this sense. The city administration must focus efforts on decentralized processing of biodegradable waste at source.

Only a multipronged strategy involving all the stakeholders – central and state governments, urban local bodies, private firms, community based organisations, non-governmental organisations and the waste producing populace at large– can help assuage the municipal solid waste crises in the city. In light of the issues highlighted, this paper makes the following recommendations:

- *Stringent implementation of legislation:* Now that legislations clearly lay down the stipulations for the management of municipal solid waste in unambiguous terms, their stringent implementation is a must. Even future alterations and additions to the legal framework must be abided by, with strict adherence to rationally imposed deadlines. For this, the urban local bodies must be held responsible.

- *Autonomy for urban local bodies:* MSWM must be a separate department in the urban local body, with a technical functionary at its helm. Following the bubonic plague epidemic scare in 1994, the Surat Municipal Corporation achieved immense success with devolution of financial and administrative powers along with a high MSWM budgetary allowance.

- *Involving the Private Sector:* The biogas subsidy is provided only for consumers. Suppliers currently receive no assistance from the government. Quality control mechanisms and operating standards must be adhered to and inspections must be carried out to weed out sub-standard systems that would cause consumers to lose faith in the technology itself due to suboptimal performance and regular breakdowns. Additionally, there must be easier access to capital for firms that deal in waste processing technologies, linkages with scientific expertise and latest advancements, and complete detachment from political interference.

- *Providing Markets:* In economic terms, any form of environmental degradation implies the presence of negative externalities that lead to a market failure wherein the price of a good or service that degrades the environment does not reflect the true cost of that good or service to the society. This leads to an inefficient allocation of resources in the economy. The ideal way to correct such a market failure and internalize the cost of using such a good or service is to follow the 'Polluter Pays' principle. Producers of non-recyclable, non-biodegradable waste (such as batteries, lamps, etc.) must be made responsible for their reuse or safe disposal. There should be some kind of buyback facility wherein people can sell these products back to the manufacturer, possibly through intermediaries. This must be enforced even if the cost of the initial product rises; it is just a question of equating social and private costs.

A biogas plant provides the user with solid and/or liquid fertilizer, along with the biogas fuel. The initial cost of a biogas plant can be recouped within 2-3 years, from the fertilizer and fuel. These fertilizers are sold via a few manure outlets (including chemical fertilizer merchandisers) and are also by some of the firms that manufacture biogas plants. Yet, currently these markets are underdeveloped and the linkages between the sources of demand and supply are few. Making a profit from compost sales will remain low for as long as the national compost market is not expanded and promoted further. (Zurbrugg et al, 2004)

- *Recycling of non-biodegradable waste:* The decentralized processing of biodegradable waste must be supplemented by recycling of non-biodegradable waste in the city itself. For this the urban local body must, in consultation with the state government, set up a recycling plant while accounting for future recycling needs too.

- *Public Education and Awareness:* Waste generators need to change their attitudes for any MSWM action plan to work in the city. Not only do they need to be aware of the need for processing of biodegradable waste, they must be dedicated to proactively working towards achieving this objective (for example, by installing biogas plants at home). Often, waste managers talk of the 'need for segregation at source'. Instead, different kinds of waste must not be mixed at all, so as to avoid the need for segregation. If nothing else, at least the biodegradable and non-biodegradable waste can be put into two separate bins. Users of biogas plants must undergo specially designed training programmes on how to operate and maintain the plant so that it maintains good operating parameters and has a long life. Outreach programmes must be implemented several times around the year, and should include advertisements in magazines, newspapers, television, FM radio personal messages, drives and clean up campaigns on social media, exhibitions and training programmes for the general public, etc.

REFERENCES

Ahluwalia I.J. & Tiwari K., 2013, '*A Note on SWM in Kerala',* Ministry of Urban Development, Government of India

Ahmed K. & Jamwal N., 2000, '*Garbage: your problem'*, Down to Earth 31, 30-45

Ambat B., 2000, *'Solid Waste Management: Preparation of an Action Plan and Establishing an Environmental Monitoring System for Thiruvananthapuram City'*, KRPLLD, Centre for Development Studies

Anilkumar A., Sukumaran D. & Vincent S.G.T., 2015, *'Effect of Municipal Solid Waste Leachate on Ground Water Quality of Thiruvananthapuram District, Kerala, India',* Applied Ecology and Environmental Sciences, vol. 3, no. 5: 151-157

Annepu Ranjith Kharvel, 2012, '*Sustainable Solid Waste Management in India'*, Waste-to-Energy Research and Technology Council (WTERT), Columbia University

Asnani P.U., (2006), '*India Infrastructure Report'*, pp.160–189, Oxford University Press

Central Public Health and Environmental Engineering Organization (CPHEEO), 2005, *'Report Of the Technical Advisory Group On Solid Waste Management',* Ministry of Urban Development, Government of India

Comptroller & Auditor General of India, 2015, '*Union Civil Performance Renewable Energy Report'*, Office of the Comptroller & Auditor General of India

Department of Economics & Statistics, Government of Kerala, 2013, *'Report on Different Aspects of Migrants and Return Migrants'*

Government of India, 2011, '*National Implementation Plan: Stockholm Convention on Persistent Organic Pollutants'*

Kumar S., Gaikwad S.A., Shekdar A.V., Kshirsagar P.S., Singh R.N., 2004, '*Estimation Method for National Methane Emission from Solid Waste Landfills'*, Atmospheric Environment 38 (2004)

Ministry of Environment & Forests, Government of India, 2000, *'Municipal Solid Waste (Management & Handling) Rules',* The Gazette of India, Part II, Section 3 – Sub-section (ii)

Ministry of Urban Development, Government of India, 2016, *'Swachh Survekshan'*, PIB

Ministry of Environment Forests & Climate Change, Government of India, 2016, *'Solid Waste Management Rules'*, The Gazette of India, Part II, Section 3 – Sub-section (ii)

Nair K. N. & Sridhar R. (Ed.), 2005, *'Cleaning up Kerala: Studies in Self-help in dealing with Solid Waste'*, Centre for Development Studies

Shyjan D. & Mohan R., 2013, '*Public-Private Partnership in Urban Solid Waste Management and its Impact on the Rural People'*, International Journal for Advanced Research in Emerging Disciplines, Vol 1, Issue 1, 53-67

Singhal S. & Pandey S., 2000. *'Solid Waste Management in India: Status and Future Direction*', TERI, Information Monitor on Environ. Sci., 6(1): 1-4.

United Nations Environment Programme, 2015, *'Global Waste Management Outlook'*

Varma A., year unknown, "*Status of Municipal Solid Waste Generation in Kerala & their characteristics',* Suchitwa Mission, http://www.sanitation.kerala.gov.in/pdf/staeof_solidwaste.pdf

Visvanathan C. & Trankler J.,2004, '*Municipal Solid Waste Management In Asia: A Comparative Analysis*', Asian Society for Environmental Protection News Letter, Thailand, Part I in V- 19, No-3, Part II in V-20, No-4, 2003

Waste Management Policy Group, 1981, *'Economic Instruments in Solid Waste Management'*, Organisation for Economic Co-operation and Development

Zurbrugg C., Drescher S., Patel A., Sharatchandra H.C., 2004, *'Decentralised Composting of Urban Waste – An Overview of Community and Private Initiatives in Indian Cities'*, Waste Management 24(7):655-62

APPENDIX – QUESTIONNARE (FOR HOUSEHOLDS)

Household Information:

Head of Household		
Age, Gender of HoH		
Name of Beneficiary		
Age, Gender of Beneficiary		
Address (Ward, area)		
Name of Initiator		
Age, Gender of Initiator		
Educational Qualification of Initiator		
No. of family members		
Family income(Annual)		
Consumer durables	4 wheeler	
	2 wheeler	
	A/C	
	TV	
	Refrigerator	
	Whether own house?	

Waste Handling:

Quantity of biodegradable waste generated	Veg	
	Non-Veg	
Quantity of non-biodegradable waste generated		
How did you dispose of your waste earlier?		
How much did it cost you?		
Did you segregate your waste back then?		
How did you come to know of Biogas?		
What was more important: *free fuel and manure* or *proper disposal of waste?*		
How did you come to know of (and contact) your turnkey (Biogas Plant) agent?		
Do you dispose of vegetarian and non-vegetarian waste together?		
Do you put the waste into the plant as it is generated or collect and dump together?		
How do you dispose of non-biodegradable waste at present?	Plastic	
	Glass	
	Dirt/Rubble (Inert)	
	Other	
Do you know of any other households that use Biogas in the vicinity? (If yes, provide number)		

Subsidy:

How did you come to know of the subsidy scheme?	
Who applied for the subsidy to ANERT?	
Did you know that there are 2 subsidy schemes (central and state governments)?	
How was the subsidy given to you?	
How long after the plant's installation did you get the subsidy?	

Biogas Plant Operation/Maintenance:

Capacity		
Year installed		
Total cost of installation (excluding subsidy)		
Time from placing the order to starting of plant		
Whether septic tank waste let into the plant?		
Daily biogas quantity (time)		
Has this quantity varied over time? If yes, then how?		
Estimated no. of LPG cylinders saved in a year		
Fertilizer quantity	Liquid	
	Solid	
How do you use/dispose off the fertilizer?		
Do you know of any way to sell the fertilizer?		
If yes, which markets do you sell it in?		
If no, would you like to have access to a market?		
Total time shutdown in a month		
Whether daily checking/cleaning performed?		
Repairs and maintenance frequency		
Yearly maintenance costs		
Commonly occurring problems in the plant		
How often can these problems be solved at home?		
Whom do you call for external help?		
How prompt is their service? (response time)		
How would you rate your turnkey agent's post-sales services? (Scale of 0 – 5, 5 being excellent)		
Would you recommend Biogas technology to other people?		