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A Sustainable Approach to the Municipal Solid Waste Management in Neyyatinkara Municipality, Kerala, India

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Abstract This paper presents the current status of municipal solid waste management (MSWM) system of Neyyatinkara, one of the municipalities of Thiruvananthapuram district, Kerala, India. The study provides an overview of generation, segregation, collection, transportation, disposal and recycling of municipal solid waste with emphasis on assessment of the type and mode of waste disposal practices followed by the households. The main objective of the study is to identify the major problems and limitations that hinder improvement in the current MSWM practices and finally suggest remedial measures. Basic information was gathered from municipality and representative ward members. A detailed field survey was carried out with documentary and photographic investigations and also using a questionnaire which was circulated among the households. The study reveals that the present system of MSWM is inadequate, as the average collection efficiency is only 45%-50% of non-segregated waste. Open dumping and burning are the prevalent approaches followed for final disposal. Unscientific methods of disposal without proper treatment create environmental pollution and human health issues. Provision of services by the municipal authority is hindered by limited budget, inadequate technical capacity, weak enforcement of laws, inadequate data on quantity of waste and its characteristics, poor urban planning, infrastructures and socio-cultural patterns. The study showed that organic waste constituted a major component of the total wastes. A decentralized action plan incorporating effective composting methods for organic waste particularly a mix of Effective microorganisms and vermicomposting is suggested as a sustainable alternative method based on analyses of the compost for total carbon, NPK and C/N ratio of four different treatments investigated. Also factors to be considered to implement Solid Waste Management (SWM) practices successfully at household level are also elaborated.

Keywords: *solid waste management, Effective Microorganisms (EM), composting, vermicomposting, organic household waste, Neyyatinkara municipality*

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1. Introduction

Solid waste management is one of the most significant challenges faced by the world today. Rapid urbanization and industrialization in the recent years has resulted in the accumulation of enormous amount of solid wastes all over. According to United Nation’s World urbanization prospects report, urban population in the world is expected to reach 66% of the total population by 2050 [22]. Solid wastes include all solid materials that the processor no longer considers of any sufficient value to retain. SWM involves the selection and application of appropriate technologies, techniques and management practices to design a program that achieves goals and objectives while minimizing operating costs and environmental harm. Management of solid waste, including the municipal solid waste (MSW) is a major challenge in urban regions of most of the world.

In India, as per 2011 Census, 285 million Indians live in urban area and are expected to rise to 550 million by the year 2021 and 800 million by 2041 [3]. With the ever increasing population and urbanization, the waste management has emerged as a huge challenge in the country. Not only the waste has increased in quantity, but the characteristics of waste have also changed tremendously over a period, with the introduction of so many new gadgets and equipment. It is estimated that about 62 million tonnes of waste is generated annually in the country, out of which 5.6 million is plastic and 0.17 million is biomedical waste. The per capita waste generation in Indian cities ranges from 0.2 to 0.6 kg per day [2]. The MSW (Management & Handling) Rules notified in 2000 by the Ministry of Environment and Forest require cooperation from municipalities and local bodies to collect waste in segregated manner and undertake safe and scientific transportation, management, processing and disposal [4]. However, most municipalities in India have failed to comply with these rules [1]. The Union Ministry of Environment, Forests and Climate Change (MOEF & CC) have recently notified the new SWM rules in 2016. The new rules are applicable beyond municipal areas and have included urban agglomerations, census towns, notified industrial townships, areas under the control of Indian Railways, airports, special economic zones, places of pilgrimage, religious and historical importance, and State and Central Government organizations.

Waste management has become a serious issue in the state of Kerala also. Emergence and re-emergence of infections have forced to open our eyes to the issues affecting environment around. Most of the municipalities in Kerala have found many difficulties to comply with the rules. In this context, a study on the MSW of Neyyattinkara Municipality in Thiruvananthanpuram District of Kerala, India was undertaken. Neyyatinkara was selected as it epitomizes the majority of the municipalities of Kerala. The aim was to prepare a status report of MSWM of Neyattinkara municipality with the following specific objectives: (1) to observe and assess the present system (2) to gather information on the problems faced by the residents on the basis of a questionnaire. (3) to suggest a better MSWM strategy suitable to the local situation

2. Study Area

Neyyatinkara is the southernmost municipality of Kerala State in the Thriruvananathapuram district (8.29N Latitude and 76.59E Longitude) (Figure 1). According to the Census 2011, it has a total area of 28.785km^2 with a population of 70850. It consists of 44 wards and for the study field observations were made in all the 44 wards of the municipal area to evaluate the present status of the waste generated and disposed.

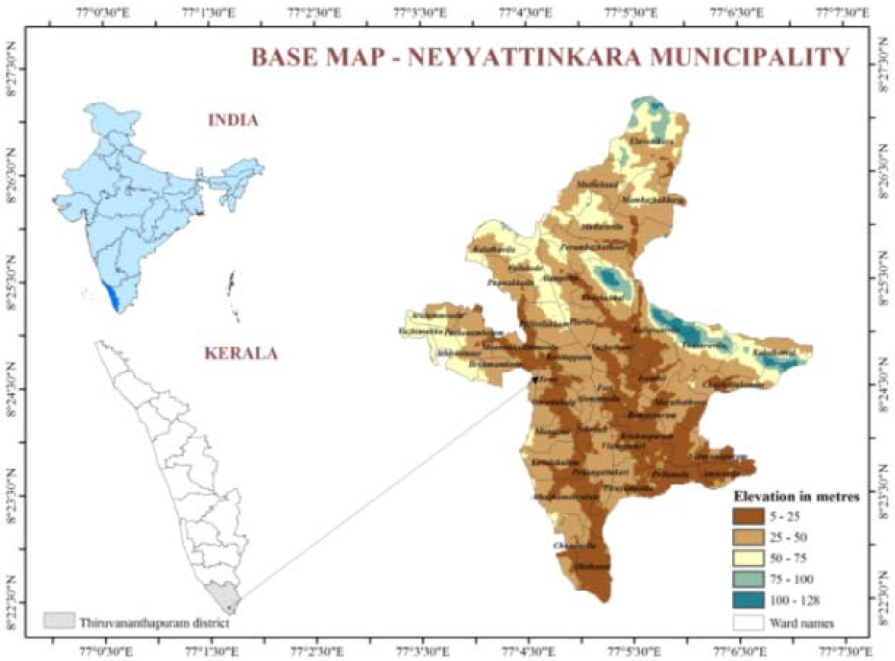

Figure 1. Base Map of Neyyatinkara Municipality

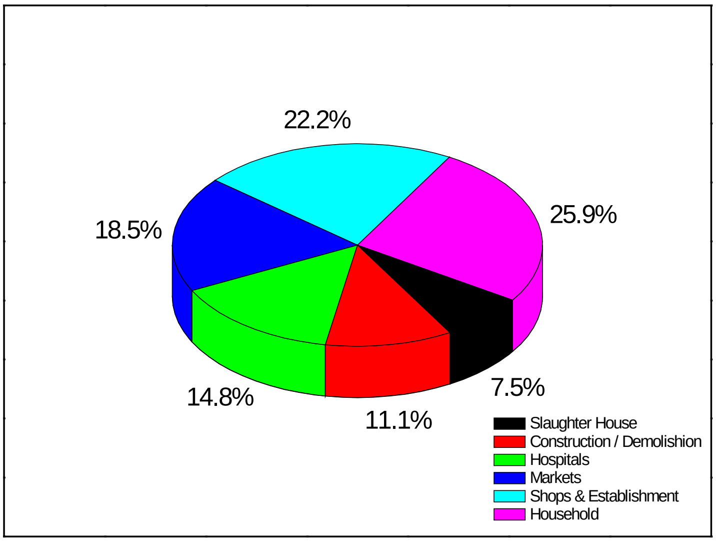

Figure 2. Sources of waste generation in Neyyatinkara

Figure 3. Littering of waste in Municipality; (a) Behind the Meat Market; (b) &(c) Road Sides; (d) On the banks of Neyyar River

Field observation showed that in Neyyatinkara, the sources of waste generation are vegetable, fruit and meat markets, households, shops, hotels, slaughter houses and hospitals, institutions, construction and demolition sites etc and their proportions are represented (Figure 2). There are six markets in the municipality. These markets generate large quantities of biodegradable waste materials like dried banana leaves, fruits, vegetables, cattle dung, etc. The municipality has one authorized slaughter house and several unauthorized ones, 23 hospitals/nursing homes, 73 religious centers, 97 hotels/ restaurants, 135 educational institutions and 18117 households. No waste storage facility has been set up in market places or near slaughter houses. It was observed that no primary waste collection was practiced in the municipality No collection bins were seen anywhere in the municipality. Wastes are disposed by crude dumping in low laying areas, roads and river banks (Figure 3).

It was further observed that segregation of waste at source is lacking. On working days the workers from the municipality collect the wastes and transport in uncovered lorry. At present no steps for processing of these wastes are followed. However, the municipality transports some of the organic wastes to the agriculturalists for field use, collecting a nominal fee from them.

3. Materials and Methods

A household survey using a questionnaire was done among the randomly selected 2% including ward members of the 44 wards of the municipality. Questions were framed with the prime objective to evaluate the demographic, socio-cultural and institutional factors and suggest an effective solid SWM practice that is environmentally sound and safe for human health. The questions were mainly (1) do they segregate household wastes into organic, inorganic and plastic for storage and disposal later phase, (2) how do they make use of the wastes or dispose the different wastes, including the practices followed for disposal, (3) whether they are satisfied with the present municipal solid waste management system of the municipality and, if not, to provide their suggestions, (4) whether they are ready for making payment for the door to door collection of waste, if arranged by the municipality and (5)whether they are willing to undertake the composting technology at home itself for managing organic waste. The questions were more focused on organic and plastic wastes since these appeared to be more problematic. The survey revealed that out of the 44 wards, 5 wards namely Town, Vlangamury, Vazhimukku, Narayanapuram and Alummoodu are facing waste disposal problems to a greater extent. Approximately 75% of the houses in these wards stored waste in plastic bags without segregation and discarded on the road side from where the municipality collects them. About 50% residents reuse plastic bottles and carry bags and 26% burn waste plastics. Most of the residents in these affected wards suggested that door to door collection may be implemented on a payment basis. The next affected wards were Aralumoodu, Amaravila, Brahmamkode, Fort, Punnakkadu, Nilamel, and Koottapana. About 60% of residents dump waste in the open space and in drains, 60% reused plastic materials and 30% burnt the waste plastics.

Approximately 33% households from Moonukallinmoodu, Vadakadu, Kalathuvila, Alampotta, Plavila, Thavaravila, Chaykottukonam, Maruthathoor, Irumbil, Krishnapuram, Chandavila, Panangattukari, Manalur, Ooruttukala and Athiyanoor found difficulty in managing wastes in their own backyard.

Other 17 wards appeared to have less problem in disposing off the waste as they were mostly agriculturists and to a greater extent found using the organic waste as manure for cultivating crops and vegetables. The plastic waste generation was also found low in these localities. 87% of residents reuse plastic carry bags and bottles. Waste plastics were burnt by 9% of residents in these wards.

Approximately 32% of the residents were not satisfied with the present solid waste management. 25% suggested that use of plastics may be restricted and substitute plastic carry bags with cloth, jute or paper bags. 42% residents were ready to practice composting; remaining argued that the main problem of the composting is odour and the long duration taken for decomposition. 45% of residents also brought up the issue of non-availability of space within the household to have the composting facility. 20% residents were willing to pay for improved SWM and this attitudinal change is significantly related to income, educational level and social awareness for maintaining an improved quality life. If door to door collection is arranged and segregation of wastes at source is practiced, the biodegradable waste can be collected and subjected to different composting processes and can be used for cultivation of crops in the 17 wards of the municipality where agricultural community is dominant. A significant part of the paper and plastics waste can be easily segregated for recycling and re-used.

From the survey it was estimated that per capita waste generation is 0.28kg/day and that the organic waste fraction makes a relatively larger contribution to the total waste (Figure 4) and it consists of mostly food remains, vegetable wastes, grass cuttings, leaves and plant remains. The paper fractions included newspapers, school books, packaging materials, paper cups, bags etc. Plastic fraction consisted mainly of plastic covers, bags, bottles, packaging containers etc. Glass includes bottles, broken glassware, light bulbs. Foils, tins, cans, appliances, etc, come under metal fraction. Textiles, leather, rubber, e-waste, etc, constitute others.

Recycling of solid wastes is now recognized as the most environmentally sound strategy for dealing with municipal solid waste as a preventive measure of source reduction and reuse [6]. The result indicated that, if recycling is to be adequately developed as an effective alternative to landfill disposal, households attitude must be improved by supporting with adequate recycling facilities strategically located and within easy reach of the households.

Since organic waste was identified as the major waste component (63%) in the municipality, an attempt was made in the present study to tackle this waste problem by subjecting it to different composting procedures enabling the residents to choose a suitable management practice [13,17].

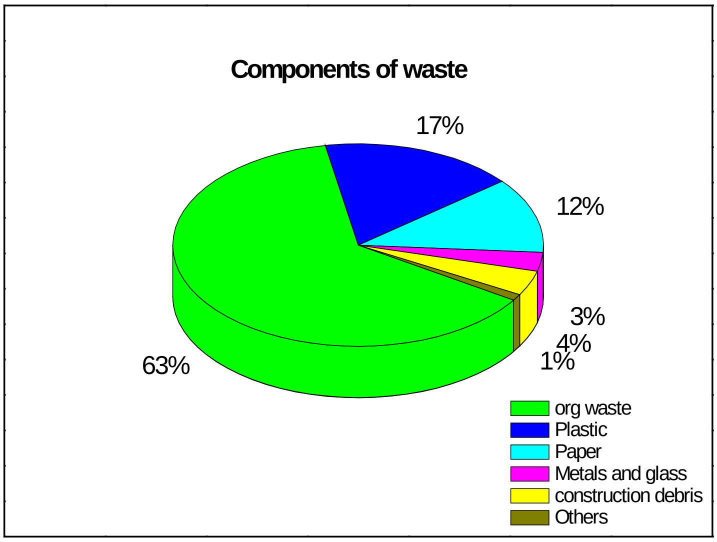

Figure 4. Composition of waste in Neyyatinkara Municipality

An investigation was carried out to suggest a suitable nuisance free composting in a fast and non laborious way. To assess the feasibility of composting and vermicomposting process, and the effect of Effective Microogranisms (EM) application [18] in managing household organic wastes, four treatment methods were applied. EM is a multi-culture of coexisting anaerobic and aerobic beneficial microorganism [5]. The objective of the study was to assess which among the listed below applications would yield the best percent volume reduction with high nutrient value to the compost produced.

(1) Cow dung + Org. waste: Treatment 1 (T1)
(2) Cow dung + Org. waste + Worms: Treatment 2 (T2)
(3) Cow dung + Org. waste + EM: Treatment 3 (T3)
(4) Cow dung + Org. waste + EM + Worms: Treatment 4 (T4).

Representative organic samples were collected from households and a homogeneous mixture was prepared with cow dung in the weight ratio of 4:1. EM solution [8] was diluted from stock in the ratio 1:1000 and sprayed to the compost pile. Earthworms of the family Eudrilus eugeniae were used in the studies. The solid waste sample was prepared for physico-chemical analysis as per Bureau of Indian Standards (IS: 9234-1979). Determination of Total organic carbon by Walkley-Black Method, Total Nitrogen by Kjeldahl digestion method [21]. Total Phosphorous by Molybdenum blue method, Potassium by flame photometer method and pH by pH meter, were carried out [9]. During the course of investigation the samples were examined in triplicate at periodic intervals of 15, 30, 45 and 60 days of composting. C/N ratio was also calculated.

4. Results and Discussion

In all the treatments volume of waste reduced considerably. After 60 days of composting, decrease in volume was T1 (48%), T2 (59%), T3 (54%) and most prominent was for T4 (61%). Significant changes in parameters such as pH, total organic carbon, nitrogen, phosphorous and potassium were noticed as composting progressed (Table 1). The change in pH from the initial alkaline to a more neutral condition was obtained for all investigations. The decrease in pH may be due to the mineralization of N and P, microbial decomposition of the organic materials [14] and hydrogen released due to lactic acid bacillus in the EM solution [15].

Total organic Carbon (TOC) losses account to 30.6 % (T_1), 35.8 %(T_2), 35.3%(T3) and 39.9 %(T_4). Maximum reduction was observed in T4 indicating high organic matter mineralization. The results agree with other researchers [11] who have reported 20 - 45% reduction of TOC to CO_2 during vermicomposting of MSW. The greater reduction in EM applied vermi composting may be due to the fact that microorganisms used the carbon as a source of energy, decomposing the organic matter at a faster rate.

Total Nitrogen (TN) TN was higher in the product than before composting and increased by 26% in T_1, 42% T_2, 23% T_3, and 33% T_4. Earthworms can boost nitrogen levels of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluids and dead tissues of worms during in vermicomposting process. At high pH values, nitrogen is lost as ammonia and hence a decrease in pH is an important factor in nitrogen retention as composting progresses. Earlier studies [12,20] have also observed similar nitrogen profile during vermicomposting process.

Total Phosphorous (TP) increased only gradually with the composting duration. This may be due to the gradual mineralization. As the study was only for 60 days, it was an expected observation. It is well reported that phosphorous mineralization and mobilization, resulting from enhanced phosphatase activity by microorganisms in the gut epithelium occurs if earthworms are reared for longer period [16].

Table 1. Changes in chemical characteristics of waste in relation to duration of composting

Time(days)	Treatment	pH	C	N	P	K	C/N
0	T1	8.13± 0.05	30.49±0.66	1.05±0.02	0.59±0.01	0.51±0.02	29.03
15		8.01± 0.04	29.15±0.79	1±0.04	0.59±0.03	0.49±0.03	29.15
30		7.82± 0.05	26.75±0.96	1.15±0.01	0.61±0.01	0.51±0.01	23.27
45		7.54±0.06	22.24±0.81	1.27±0.03	0.62±0.01	0.52±0.01	17.51
60		7.32±0.08	21.13±0.99	1.32±0.04	0.63±0.02	0.54±0.04	16.00
0	T2	8.23± 0.08	30.41±1.04	0.98±0.03	0.6±0.03	0.5±0.03	31.03
15		8.06±0.06	28.42±1.01	0.95±0.02	0.64±0.01	0.54±0.01	29.91
30		7.63±0.08	21.51±1.05	1.17±0.01	0.69±0.05	0.59±0.07	18.38
45		7.29±0.09	19.92±0.41	1.29±0.03	0.71±0.06	0.64±0.03	15.44
60		7.02±0.07	19.51±1.45	1.39±0.02	0.75±0.04	0.66±0.04	14.03
0	T3	7.87± 0.09	30.93±1.66	1.1±0.03	0.63±0.01	0.53±0.04	28.12
15		7.74±0.07	27.34±1.42	1.02±0.04	0.66±0.02	0.55±0.01	26.80
30		7.53±0.04	23.59±0.81	1.21±0.04	0.67±0.04	0.59±0.02	19.50
45		7.19±0.02	21.1±0.762	1.3±0.02	0.69±0.03	0.61±0.08	16.23
60		7.11±0.06	19.99±0.18	1.35±0.05	0.69±0.05	0.62±0.04	14.81
0	T4	7.87± 0.09	30.93±1.66	1.1±0.03	0.63±0.01	0.53±0.04	28.12
15		7.64±0.02	28.46±0.91	1.05±0.01	0.68±0.07	0.59±0.01	27.10
30		7.35±0.05	24.34±0.62	1.25±0.05	0.74±0.00	0.65±0.03	19.47
45		7.08±0.01	20.85±0.75	1.39±0.03	0.79±0.04	0.67±0.04	15.00
60		6.99±0.02	18.81±0.61	1.42±0.02	0.81±0.01	0.68±0.01	13.25

Total potassium (TK) increased gradually and maximum 0.68 was observed for T4.

Carbon/Nitrogen (C/N) of the substrate material reflects the organic waste mineralization and stabilization during the process of composting or vermicomposting. Higher C/N ratio indicates slow degradation of substrate and lowers the C/N ratio higher efficiency level. The loss of carbon through microbial respiration and simultaneous addition of nitrogen in the form of mucus and excretory material by worms may be the reason for the greater C/N reduction in T4. If the C/N ratio of the compost is more, excess carbon tends to utilize nitrogen to build cell protoplasm. This results in loss of nitrogen in the soil. If C/N ratio is too low, it cannot improve the structure of soil and thereby its manure value is less. Hence an optimum C/N of ≤ 20 is desirable [19]. Hence the final composts obtained from all 4 treatments are excellent manure on the basis of the C/N ratio [7], [10]. Statistical analysis of the data showed significant variance ($P < 0.05$) on 15, 30th and 45th day of composting as per ANOVA for all the parameters.

5. Conclusion

The study illustrates that solid waste disposal practice in Neyyatinkara is to be addressed more seriously. Even though municipality is legally responsible for collection and disposal of waste, presently there is no consistent database on waste management. It was, however, observed that there are no good waste management practices like collection, separation, disposal methods and recycling in the study area. It has been found that open dumping which is the crude method of waste disposal is the current practice followed. Similarly, because of poor waste management system, the disposal of solid waste is mostly along the roads and river banks.

The sorting and segregation of solid waste could be done at the house level and it will be easier for biodegradable and non-biodegradable waste to be effectively managed. This segregation could also help in resource recovery of some solid waste that could be recycled to produce fertilizers. Aiming at an efficient bio-transformation of organic wastes, four different treatment modifications were experimented and changes in the nutrient value of the compost as composting proceeds at an interval of 15 days until it obtains maturity/stabilization were also evaluated. It revealed that the best quality compost was obtained in T4. It can be concluded from the result that application of EM solution and subsequent vermicomposting could significantly reduce the volume of the waste and high nutrient rich compost could be obtained. In addition the problem of foul smell or bad odor was completely overcome by this treatment.

It is highly recommended that the four R's (Reduce, Reuse, Recycle and Restoration) of effective management of waste resources should also be implemented for a complete solution to the problem. The reuse of certain products should also be encouraged. Plastic plates, spoons and cups of good quality used for special occasions could be cleaned and reused instead of being disposed. Finally, to efficiently manage municipal solid waste, there is need for a better initiative and co-operation between the municipality, public, producers, environmental and non-governmental organizations. A holistic approach is the need of the hour which can be attained through decentralization process. The willingness of the public to pay for improved SWM must be favorably considered for developing economically feasible strategies for solid waste management. From these perspectives we can achieve the much needed goal of sustainable urban solid waste management in Neyyatinkara.

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