A DECISION MAKING TOOL - DESIGN OF COMMUNITY STORAGE SYSTEM FOR SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT

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***Abstract*:The Municipal Solid Waste (MSW) management is a complex service that should be provided with suitable and feasible technologies in developing countries like India. The collection element plays a vital role in the MSW management. Hence, the planning and design of community bins make a greater impact on the environment. In this regard, an application model called Design of Community Storage System (DCSS) was developed using .NET programme. This model considered the assessment factors such as waste generation, size of the bin, collection frequency, number of bins, catchment area and bin density etc., Also the model enables the resource consumption during the community bin production and the emissions on air, water and industrial soil. This developed tool audits the policy makers to understand degree of environmental impact during decision stage. The practical implementation of this tool for the Coimbatore city shows the potential application for continuous improvement of municipal solid waste management in the design of community storage bins at the local level.**

Key words: Municipal Solid Waste, Design of Community Storage System, Community Storage Bin, Size and Number of Bins, Collection Frequency, Material required for bin Production

I. INTRODUCTION

The escalating amount of Solid Waste from municipalities and its consequent disposal is being a major bottleneck in developing countries like India. Rajendra Kumar Kaushal et al (2012) stated that the projected Municipal Solid Waste (MSW) quantities in India are expected to increase from 83.8 million tons in 2015 and 221 million tons in 2030.It is also reported that per capita per day production will increase from 0.6 kg to 1 .032 kg and urban population as 586 million in 2030.This hasty increase of MSW makes more social responsible on stakeholders for smooth and successful MSW management. Generally, the Urban Local Bodies (ULBs) undertake major tasks in delivering their services with regard to manpower, equipments, infrastructure and funds [12]. Sometimes, the underestimation of MSW generation leads problem in the setting up of infrastructural facilities in the collection system. The result is in the form of open dumps and overflowing of MSW containers at official dump sites. Hence, an accurate design and planning of each component is essential in MSW management.

Moreover, an appropriate MSW management and better technology applications are necessary for an effective and efficient handling of MSW [2]. Hence, a definite development of a comprehensive and user friendly Environmental Decision Support Systems (EDSS) for MSW management are essential for regulative and social set up [12]. Barlishen and Baetz (1996) developed a planning tool for MSW forecasting, technology evaluation, recycling & compost design, facility sizing using knowledge based system components with spreadsheet, optimization and simulation models. In India, various models for MSW collection and transportation route planning and optimized landfill site selection were built up by using expert systems, GIS and remote sensing technique [8,16,17 and 18].

From the context of background information, the EDSS could be applied in various functional elements of MSW management. In this regard, the prominence is given for finding number of community bins and the emission during their productions at the municipal level for sustainable MSW management. Therefore, an user friendly interactive application model called as Design of Community Storage System (DCSS) was developed using .NET programming on windows XP platform for the design of the community bins. This strongly depends upon MSW generation quantity, size of the bin, collection frequency, catchment area and the bins life time and recycling rate after the disposal of the bin. The material used for the bin production is High-Density Polyethylene (HDPE). This model incorporates two modules for degradable and recyclable MSW separately. The developed model was designed for repeated use of municipal representatives and also appropriately to assess the number of bins for ULB in Coimbatore city, India.

In order to support the decision makers, concerning the design of community bins, the planning horizon was defined for a period of 50 years. This model generates a set of flexible MSW management planning for the storage of degradable and recyclable waste separately. This paper describes the functional design of DCSS, the interfaces and potential application of the DCSS tool for Coimbatore city and the frame work is illustrated in Fig.1. This model could be used as a decision making aid for continuous improvement of MSW management at the municipal level.

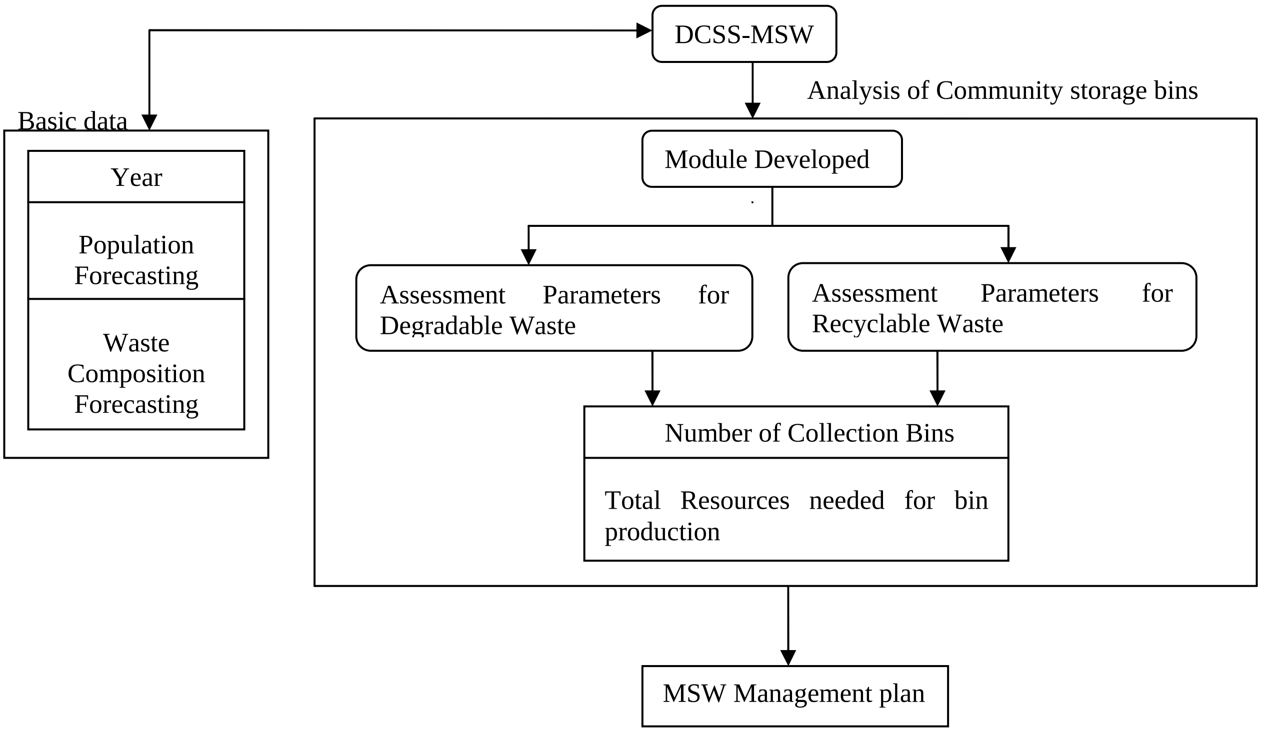

Fig.1 Frame Work of DCSS model

II. DEVELOPMENT AND STRUCURE OF THE DCSS

Several models have been developed in recent decades to support decision making in MSW management. In the 1990s the factors considered in MSW management model were principally economic, environmental and technological. Numerous studies were applied on Life Cycle Assessment to evaluate the environmental impact of MSW management alternatives [4, 7, 13, 14]. In recent years, MSW management models have stressed sustainability and can be divided into two categories. One category addresses social factors in the decision making methods [5] whereas the other category incorporates public participation into the decision making process. Ananda and Hearth (2003), Morrissey and Browne (2004) proposed that a sustainable MSW management model should be environmentally effective, economically affordable and socially acceptable.

The numerical results and graphical outputs from the database management can be presented to the users. The DCSS model developed here to help the decision makers to allocate the optimal number of bins and the size of the bins based on the population, bin density, catchment area and collection frequency.

The proposed interactive DCSS model handles a large amount of background information which may need to be collected, rearranged and analyzed before the decision making is performed for the design of community storage bins. Accurate predictions and the design of community storage bin rely on the better management information system regarding data on collection, population and the availability of the collection vehicles. The number of available vehicles determines the collection frequency. Furthermore the DCSS is needed to provide user friendly interface for the analysis and to communicate the decision makers or a planner, who may not able to memorize the entire message, of integrating all the necessary factors.

Further, the developed model is used to estimate the required material and emissions during the production of HDPE bins. Since this is the more predominant for the evaluation of the environmental impact of using HDPE bin.

FUNCTIONAL DESIGN OF DCSS

A.General Details

In the DCSS, the fornt end was designed using VB.NET. The modeling is emphasized to calculate the total number of bins separately for collection of degradable and recyclable MSW. The first screen shows the general information about the country, city, area of the city, year of waste to be generated etc., and it is shown in the Fig.2. Further, the population is projected till the year 2050 using geometrical increase method.

If the user chooses the text box to assess waste quantity, the quantities of degradable waste and their compositions such as organic biomass, woody biomass and paper are displayed in the Fig.3. Also Fig.3 shows the list of information about the recyclable waste and their compositions.

B.Assessment Parameters

The assessment of the number of community collection bins is based on the following parameters

- Generation of MSW
- Size of the bin
- Collection frequency
- Catchment area
- Biodegradable and recyclable fraction
- Bin density and
- Average filling rate of the bin.

The population is the most predominant influencing factor for the generation of MSW. Hence in DCSS model, the total quantity of MSW generation with compositions was assessed based on the population and per capita MSW generation. The size of the collection bins are to be appropriate based on the collection system. The sizes of the bins were considered as 80, 120, 240, 660, 770, 1100, 2500, 3200 and 5000 L. The collection frequency is the number of times collection provided for a given period of time. The various collection frequencies such as 26, 52,104, 156, 208, 260 and 312 times in a year were considered for model development. The size of the bin and collection frequency can be chosen based on the decision needed to municipal representatives.

These two factors depend on the number of available collection vehicle which varies from municipality to municipality.The selection of higher collection frequency will make a lower number of collection repositories. The catchment area is the area served by each bin. The serving of the bin is to be considered with bin location and proximity distance. The biodegradable and recyclable fraction is the ratio of the product of the quantity of each waste composition and their respective density to the total waste. The bin density is the number of persons covering by each bin. Generally, the type of MSW generation influences the bin density. The average filing rate is the correction factor considered as 80 percent since the collection bins are not totally filled at every collection cycle.

Then the quantity of material required for manufacturing of High Density Polyethylene (HDPE) bins, and the emissions on air, water & industrial soil for the degradable and recyclable wastes were also found. The Fig.4 and Fig.5 shows the assessment parameters for degradable and recyclable waste separately. From the developed model, it is evident that the location of bin could either

i. to locate the degradable bin adjacent to the recyclable bin or

ii. to locate the recyclable bins randomly at different locations in the city.

The first option indicates to select the different size of bins for degradable and recyclable waste to cover the same catchment area. Nevertheless, the collection frequency for recyclable waste may be extending than degradable waste. The second option shows that the catchment area for both the bins is not same.

Fig.2 General information about the city

Fig.3 Quantity of degradable and recyclable waste composition

IV. APPLICATION OF DCSS-CASE STUDY AT COIMBATORE CITY

The Coimbatore city is situated in south India and it is around 11° North latitude, 77° East longitude and 432.0 m above the mean sea level. The city had 72 administrative wards and recently the corporation boundary has been expanded to 100 wards with the area of 265.36 Km^2. It has an urban population of 9.31 lakhs as per 2001 census and the provisional population as of 2010 is about 10.59 lakhs (CMC). The city generates an average amount of MSW is about 635 MT per day (Jawaharlal Nehru National Urban Renewal Mission (JnNURM), Detailed Project Report on Solid Waste Management for Coimbatore City, 2006).

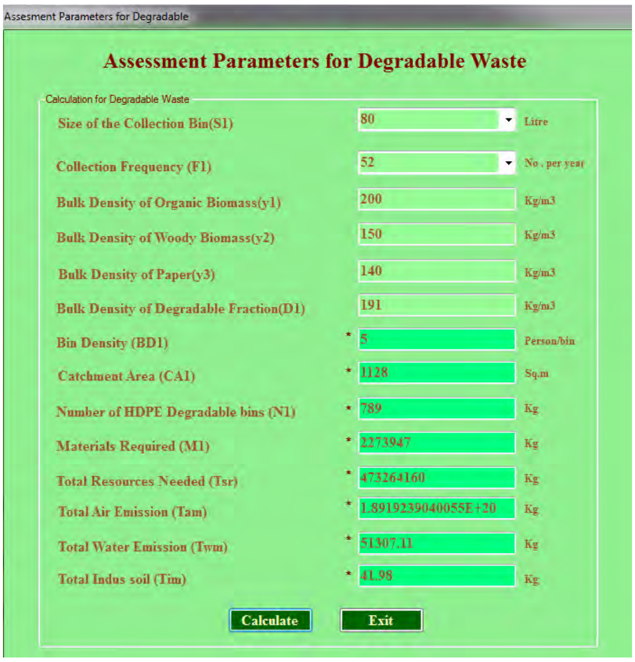

Fig.4 Assessment parameters for degradable waste

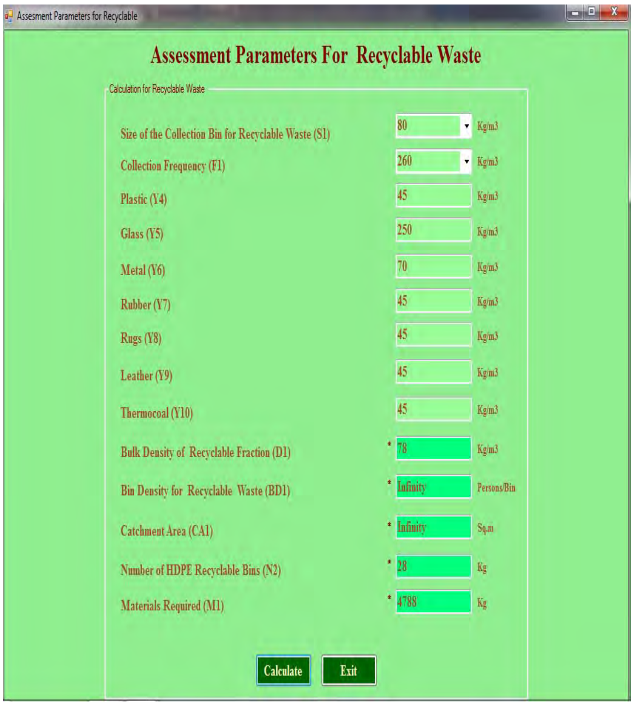

Fig.5 Assessment parameters for recyclable waste

The city presently consists of four transfer stations from where the wastes are transferred to disposal site which is situated in the place called Vellalore. Source segregation of waste is not properly being practiced. The two collection services such as an alley and door to door collections are followed in the city for collecting commingled MSW. The door to door collection services dumps the MSW into the nearby collection bins. Since the collection frequency is varying bin to bin in the alley services, the door to door services find the place to dump. If the roadside collection bins are filled completely, the door to door collection dumps the MSW around the bin.

Rapid urbanization has led to over-stressing urban infrastructure services including MSW management because of poor resources and the inadequacies of the existing systems. Therefore, augmentation of the MSW management facilities and their operation & maintenance in a sustainable manner by urban local bodies would require huge capital investment, the introduction of the latest technologies which are cost effective. Public-

Private Partnership (PPP) in waste management and the introduction of appropriate waste management practices is needed in order to prevent urban waste causing environmental pollution and health hazards.

The Coimbatore Municipal Corporation is planning to involve private entrepreneurs to deal with the problem of MSW management. In this regard, the corporation is planning to supply 200 tons per day of biodegradable waste and 30 tons per day of recyclable waste for the composting plant and recyclable yard respectively that are operated by private entrepreneurs. Recycling waste is an attractive strategy for governing officials because of its potential to reduce disposal costs, conserve available landfill capacity and contribute to national goals of energy and resource conservation [6].

The short-term predictions on the generation of MSW for the design of community storage bins can facilitate better understanding with respect to the collection, transportation and final disposal of MSW. The long term forecasting could be very useful to management organizers to select appropriate design strategies to reduce the GWP. So the above developed model is applied in the study area up to the year 2050. For an example, the composition of MSW generated for the year 2012 from the model is presented in the table. 1. As per the assessment of CMC, 76.95 percent of degradablewaste is being generated in the city, so the larger size of the bin and collection frequency may be provided than recyclable waste. The inert material was excluded from the model. By selecting the bin size as 1100 L and collection frequency as 156 (excluding Sundays), 23 numbers of collection bins were obtained for degradable waste. Three numbers of bins for each recyclable material were obtained for the size of bins of 240 L and collection frequency as weekly once. The material required for 23 and 3 number of HDPE bin production was 160.71 ton and 0.414 ton respectively. McDoughall et al., 2008 indicated that the emission of CO_2 from the production of one tone of HDPE bin from the virgin plastic material is about 3.53 X 10^6 g. Hence, the 160.71 tone of virgin plastic material emits 567.3 x10^6 g of CO_2. Thus rather than using of virgin plastic all the times, the recyclable plastics are to be used.

TABLE I
Composition of MSW generated for the year 2012
(Source: Percentage of Waste Compositition was taken from the Detailed Project Report
on Solid Waste Management for Coimbatore City, 2006)

TYPE OF WASTE	WEIGHT OF MSW IN MT/D	TOTAL WEIGHT IN MT/D
1. DEGRADABLE		
ORGANIC /BIO MASS	507.25	
WOOD	95.55	612.77
PAPER	9.95	
2. RECYCLABLE		
PLASTIC	17.47	
GLASS	1.99	
METAL	2.70	
RUBBER	9.65	44.2
RUGS/TEXTILES	7.93	
LEATHER	4.0	
THERMOCOL	0.37	
3. INERT	139.35	139.35
TOTAL		**796.32**

V.CONCLUSIONS

This DCSS application tool presents a new area of building in the design of community storage bins for MSW at the municipal level. The available number of collection vehicles for MSW varies in each municipality. So, in this programming technique, the choice is given to choose the collection frequency of the MSW. In the decision making phase, a choice of alternative is given to decide the size of the bin and the number of the bins for both degradable and recyclable waste separately for a continuous period of forty years. It also indirectly quantifies the environmental impact caused in the production of bins which helps the decision makers to choose the alternatives in the tool.

Thus the DCSS sustainable decision making model presented in this study has the following goals. 1. Assist policy makers to design community storage bins considering environmental aspects. 2. Understand the degree of impact among the stakeholders regarding the particular alternatives and 3. Help the decision makers to resolve potential conflicts during the decision making stage.

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