CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 GENERAL

It is evident from the solid waste characterization that the waste should be managed in an appropriate way for sustainable SWM. Accordingly, the different units designed for the landfills necessitated the design of composting yard, runoff collection basins curing piles, for the Hosur town.

7.2 MUNICIPAL SOLID WASTE MANAGEMENT

From the present study following conclusion can be drawn.

- Average MSW generation rate was 0.316 kg/capita/day.

- The percentage of organic content in the solid waste range from minimum of 44 to 52 percent, a value slightly higher than other cities due to more inputs from agricultural and floriculture practices show that, it can be converted into organic manure by composting method.

- The maximum and minimum range of plastics materials in the solid waste varies from 6 to 8 percent. Therefore it can be concluded that recovery and be use of plastics can be made instead of disposing into environment.

- The percentage of paper varies from 3.9 to 5.22 percent therefore it can concluded that incineration method can be adopted for burning of paper and other combustible materials such as clothes hazardous wastes, bones , leafs, coconut shells, and jute.

- The average moisture content of Municipal solid waste was found to be 37.86 percent therefore it is necessary to dry in an open area before sending for composting.

- The pH of the MSW ranges from 5.99 to 6.7, hence it is concluded it will be helpful for composting process.

- potassium, phosphorus, carbon, nitrogen varied between 2.7 to 3.0%, 1.5 to 2.3%, 0.9 to 1.3%, 1.57 to 1.85% during pre-monsoon and the values varied between 2.3 to 3.2%, 1.5 to 2.6%, 1.0 to 1.14% and 1.1 to 2.3% during the monsoon season. This indicates the organic manure of SW is rich in nutrients.

- The C:N ratio varied between 20.33 to 36.1 with an average of 27.88 during pre-monsoon and the values varied between 20.22 to 36.11 with an average value of 27.23 during monsoon season which indicates it is suitable for composting.

- The density varies from a minimum value of 351.60kg/m^3, the average density of solid waste in residential area and commercial area were 383.12kg/m^3. Average density of solid waste in residential area and commercial area were 394.54kg/m^3 and 371.71kg/m^3. These values are within the standard range.

- Moisture content varies from minimum of 36.60% to the average of 37.86%. The Avg M/C in the residential areas 37.70% and the Avg % M/C in Commercial areas 38.02%.The value is slightly higher than the standard values of 25.81% as per manual of MSWM.

- From the manova technique using SPSS software, the analysis shows that there is a considerable difference in the parameters of chemical composition of solid waste with respect to season, *i.e.,* the composition of municipal solid waste will change according to season.

- Also the chemical composition of municipal solid waste will change according to source of waste.

- The result shows that there is a significant combined effect of both season and source of waste on the chemical composition of municipal solid waste.

- The nitrogen, potassium and phosphorus content in the solid waste vary from 2.7 to 3 percent, 1.5 to 2.3 percent and 0.9 to 1.3 percent respectively. This indicates the organic manure of solid waste is rich in nutrients.

Hence, it can be concluded that the waste can be managed successfully by composting.

7.3 MANGO WASTE MANAGEMENT

From composting of mango waste it can be concluded

- The study reveals that from composting of mango waste with the poultry waste & cow dung gave very good quality of compost.
- It was concluded that an average of 10 tons of waste is generated per day from the mango market in a peak season.
- The percentage decrease in the carbon and nitrogen was mainly due to increase microbial growth in the mixture.
- The weight proportions 1:1:1 and 2:1:1 without seed gives good result when compared to other mixed weight proportions.
- It can be concluded that the waste mixture without seeds can be composted faster than the mango waste with the seeds.
- Sample 1 and sample 3 with moisture content of 40% give better compost at 35 days time.
- Co-composting of these waste materials is an example of how different waste streams may be treated in an integrated way.

7.4 VERMI COMPOSTING OF VEGETABLE MARKET WASTE

- The total quantity of vegetables arrived to the market was estimated to be 200 MT per day and vegetable market wastes approximately generated to be 6 MT per day(3 percent).

- The study shows that the vermi composting is an efficient process that stabilizes the vegetable market wastes.

- The study reveals that the good quality of bio-compost was obtained in 40 days.

- Vermi-compost is a valuable input for sustainable agriculture and waste land development Municipal corporations will have to adopt the vermi compost technology to fetch revenue.

- The carbon content present in the organics was utilized as source of energy for earthworms, and simultaneously the nitrogen is being recycled. During this process earthworms enriches the macronutrients such as N, P, and K and hence Bio-compost will becomes as an organic fertilizer.

- At the same time it proves that it is efficient method in managing to solve the problems arising for their disposal & other adverse effects of vegetable waste at the market.

7.5 IMPACT ASSESSMENT OF DUMP SITE ON GROUNDWATER AND SOIL QUALITY

- It is evident from the observations that the causes and sources of pollution in the study area are due to onsite disposal system of the solid waste.

- Dump site effects on polluting soil and water shall be stopped.

- The quality of groundwater near MSW dumping site is unsuitable for human consumption.
- The soil was also affected due to dump site of solid waste.
- The parameters like soil pH, electrical conductivity phosphates, zinc, iron, potassium, and chlorides etc., exceeded the permissible value.
- It can be concluded that the selection of dumping site is more important to protect the various environmental attributes.
- The pH values are found to be within the permissible limits of 6.5 to 8.5.
- The EC is found to be higher in few of the water samples analyzed. It ranged from 630 to 3035 µs/cm where higher concentration is reported with in 500 m radius from the MSW dumping site.
- The total dissolved solid values were found to be higher in 3 out of 8 water samples analyzed.
- Similarly calcium, magnesium, sodium, chlorides and nitrate concentrations were found to be high in a few water samples except sulphate which was found to be within the prescribed limits.
- The microbial load was high in the leachate, lesser in the groundwater of the dumping yard and low in the groundwater collected 100ft away from the dumping yard.

7.6 SITE FEASIBILITY ANALYSIS USING GIS AND RIAM

- Results of the study are derived from different thematic layers such as geomorphology, slope and vegetation.

- The slope of the area is classified into different categories like very high, high, medium, gentle slope.

- In that gentle slope preferred for suitable site for solid waste dumping site.

- Ideal sites for solid waste disposal were identified using GIS, are Belagondapalli, Nagaondapalli and Achattipalli regions.

- The identified location is cross verified with the Rapid Impact Assessment Matrix (RIAM), which depict the significant positive impact to the environment by the proposed solid waste disposal system.

- From the RIAM analysis, the cumulative impact score represent the present solid waste disposal form is Significantly Positive Impact (D).

- Biological components like foul smell, sewage are considerable impact in negative side which needs to be taking in to consideration while designing the landfill.

- In Economical components are indicate the positive impacts and in sociological, housefly and other insects need to take care while design the optimum layout for the landfill consideration.

- This study has shown how GIS, Remote sensing & RIAM techniques may be used to protect the health and safety of Hosur, by showing how town planning managers may minimize the impacts of waste disposal on the environment and the economy.

- A design for SWMS is proposed which includes waste segregation, treatment and disposal, capacity of engineered sanitary land fill required, liner and leachate collection system, design of composting yard, design of multiple chamber incinerator and layout of the facility.

- The plan, longitudinal and cross sectional views of the landfill site are given in the design.

7.7 RECOMMENDATIONS

- Route optimization technique can be adopted to select the shortest route for economical feasibility of land fill site.

- Separate Mango Market if established by Hosur Municipal Corporation it can render good revenue generation from the mango waste by converting into useful end product by blending with poultry waste and cow dung.

- The Bathalapalli vegetable market waste and Uzhavar santhai vegetable market waste can be converted into useful end product called Bio-compost by adopting vermi-composting method.

- Grid based SWM of Hosur for the different areas as the controlled domain with GIS tools.

- UASB reactor techniques for Thoropalli and Bethalapalli on pilot plant basis can be studied.
- Investigation can also be extended for the safe handling of hazardous waste being generated from Shantinagar area.
- To go for long term sustainable solution aiming at zero waste management.
- To go for enzyme based plants for quick conversion of organic waste into organic manure to be located in high waste generating areas.
- To educate the people and to create public awareness for managing the waste.
- To manage the SW arising in & around Hosur, to provide a clean environment over the entire area.
- Incentive based plastic & other recyclable waste clearance for local rag pickers.
- Dedicated garbage clearance teams for high waste generating areas.
- Rewards/recognition, scholarship for children etc for municipal sanitation workers.

ANNEXURE 1

A1.1 ROLE OF PUBLIC PARTICIPATION:

One of the important environment problems faced by urban cities is solid waste management. Increasing population, unplanned urbanization and limited alternative solution make the problem more threatening. The amount of solid waste generated is simply higher than the handling capacity of local municipal authorities and far higher than the ability of natural environment to administrate it. As a result, wastes are disposed unscientifically madding to serious catastrophic environment.

The waste management system in India is starved of resources to meet the demand of waste disposal, mounting due to increasing urbanization. The services provided by the municipal authorities for the most part are inefficient. Thus the limited capability of municipalities makes us to reach for alternative to explore the potential of utilizing community resources by their participation in waste management.

A1.2 COMMUNITY PARTICIPATION:

The word community in solid waste management means a neighbor hood group, either incidental or commercial, that utilizes a particular space in the city for their residential or livelihood purposes, Community participates in such a context could take the form of organization of the particular neighborhood group to manage the waste they have generated on the day to day basis. In a broad sense community participation entails neighborhood groups to manage the waste they have generated on day to day basis. In a broad sense community participation details neighborhood groups being aware of project cycle and able to participate in various capacities of generation and managers of the waste community participation has to be generated systematically. A model of community participation is shown in the Figure A1.1.

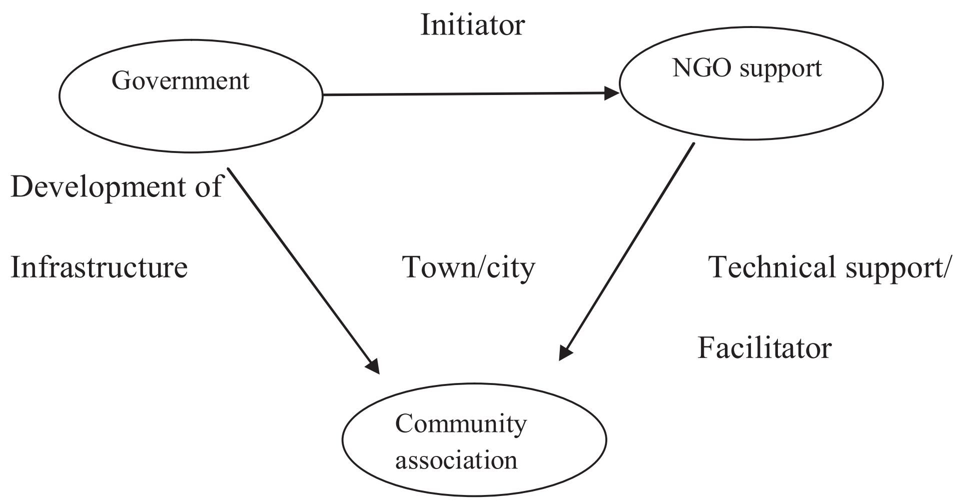

Figure A1.1 Model of Community Participation

A1.3 ROLE OF GOVERNMENT

The main role of government is to provide conductive environment for community participation. The government should manage the basic infrastructure and initial instrument for running the project. It should exist in cresting awareness and the educating the ill effects of solid waste if handle unscientifically. It should maintain the healthy co-ordination and co-operation with NGO's and community welfare association.

A1.4 ROLE OF NGO'S

NGO'S work for social concern. The main role of NGO's is to act as a facilitator between government and community citizens. They play a key role in launching the project on several issues such as conducting and surveying to identify the needs of the community, interacting with the community people to know the cause of the problem and also motivating them to participate in solving the problem collectively, training community workers and producing technical and financial assistances.

A1.5 ROLE OF COMMUNITY ASSOCIATION OR WELFARE

The core element in the community participators is community association or welfare association of the respective communities. The first step in community participation is to form an association or an organization with an objective to maintain a service of common purpose. The community will participate and involve activity only when they preview a tangible and direct benefit to the community members.

A1.6 ROLE OF PUBLIC PARTICIPATION FOR HOSUR TOWN

Previously a private organization, Srinivasa Services Trust (TVS group) was collecting garbage in the bus stand and segregates the waste for producing vermicompost and being stopped. Titan Company organized a Citizen-based programme to keep Hosur clean in the year 2012 by joining hands with Adhiyamaan College NSS students. The Photographic view 1.1 shows the public participation by the Adhiyamaan college NSS students.

The major activities involved in that programme are:

- A One-day Citizen's led clean Hosur project, possibly involving about 12,000 Citizen of Hosur working together and cleaning up the town on 8th January 2012.

- The publics of various parts of Hosur came together to continue the good work and keep their localities clean.

The main objective of that programme is to provide a sustainable solution to the problem of garbage clearance and management in Hosur in a spirit of employee and Citizen volunteering and ensure a clean Hosur which becomes a model to other urban settlements.

To clean up the Hosur town is a difficult task, but not impossible. All we require is a coming together of the entire community for this common purpose with uncommon zeal.

ANNEXURE II

A2.1 GLM MULTIVARIATE ANALYSIS

The GLM Multivariate procedure provides regression analysis and analysis of variance for multiple dependent variables by one or more factor variables or covariates. The factor variables divide the population into groups. Using this general linear model procedure, we can test null hypotheses about the effects of factor variables on the means of various groupings of a joint distribution of dependent variables. We can investigate interactions between factors as well as the effects of individual factors. In addition, the effects of covariates and covariate interactions with factors can be included. For regression analysis, the independent (predictor) variables are specified as covariates.

Both balanced and unbalanced models can be tested. A design is balanced if each cell in the model contains the same number of cases. In a multivariate model, the sums of squares due to the effects in the model and error sums of squares are in matrix form rather than the scalar form found in univariate analysis. These matrices are called SSCP (sums-of-squares and cross-products) matrices. If more than one dependent variable is specified, the multivariate analysis of variance using Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's largest root criterion with approximate F statistic are provided as well as the univariate analysis of variance for each dependent variable. In addition to testing hypotheses, GLM Multivariate produces estimates of parameters.

Commonly used a priori contrasts are available to perform hypothesis testing. Additionally, after an overall F test has shown significance, we can use post hoc tests to evaluate differences among specific means. Estimated marginal means give estimates of predicted mean values for the cells in the model, and profile plots (interaction plots) of these means allow you to visualize some of the relationships easily. The post hoc multiple comparison tests are performed for each dependent variable separately.

A2.1.1 Introduction

Multivariate analysis of variance (MANOVA) is simply an ANOVA with several dependent variables. That is to say, ANOVA tests for the difference in means between two or more groups, while MANOVA tests for the difference in two or more vectors of means.

For example, we may conduct a study where we try two different textbooks, and we are interested in the students' improvements in math and physics. In that case, improvements in math and physics are the two dependent variables, and our hypothesis is that both together are affected by the difference in textbooks. A multivariate analysis of variance (MANOVA) could be used to test this hypothesis. Instead of a univariate F value, we would obtain a multivariate F value (Wilks' λ) based on a comparison of the error variance/covariance matrix and the effect variance/covariance matrix, including Hotel ling’s trace and Pillai's criterion. The "covariance" here is included because the two measures are probably correlated and we must take this correlation into account when performing the significance test. Testing the multiple dependent variables is accomplished by creating new dependent variables that maximize group differences. These artificial dependent variables are linear combinations of the measured dependent variables.

If the overall multivariate test is significant, we conclude that the respective effect is significant. In fact, after obtaining a significant multivariate test for a particular main effect or interaction, customarily one would examine the univariate F tests for each variable to interpret the respective effect. In other words, one would identify the specific dependent variables that contributed to the significant overall effect.

MANOVA is useful in experimental situations where at least some of the independent variables are manipulated. It has several advantages over ANOVA. First, by measuring several dependent variables in a single experiment, there is a better chance of discovering which factor is truly important. Second, it can protect against Type I errors that might occur if multiple ANOVA's were conducted independently. Additionally, it can reveal differences not discovered by ANOVA tests. However, there are several cautions as well. It is a substantially more complicated design than ANOVA, and therefore there can be some ambiguity about which independent variable affects each dependent variable. Thus, the observer must make many potentially subjective assumptions. Moreover, one degree of freedom is lost for each dependent variable that is added. The gain of power obtained from decreased SS error may be offset by the loss in these degrees of freedom. Finally, the dependent variables should be largely uncorrelated. If the dependent variables are highly correlated, there is little advantage in including more than one in the test given the resultant loss in degrees of freedom.

The error variance is computed (SS error) by adding up the sums of squares within each group. If the variances in the two groups are different from each other, then adding the two together is not appropriate, and will not yield an estimate of the common within-group variance. Homoscedasticity can be examined graphically or by means of a number of statistical tests.

A2.1.2 Web pages

Site	Link
Statsoft text entry on MANOVA	http://www.statsoft.com/textbook/stathome.html
EPA Statistical Primer	http://www.epa.gov/bioindicators/primer/html/manova.html
Introduction to MANOVA	http://ibgwww.colorado.edu/~carey/p7291dir/handouts/manova1.pdf
Practical guide to MANOVA for SAS	http://ibgwww.colorado.edu/~carey/p7291dir/handouts/manova2.pdf

A2.1.3 Computations

First, the total sum-of-squares is partitioned into the sum-of-squares between groups (SS_{bg}) and the sum-of-squares within groups (SS_{wg}): $SS_{tot} = SS_{bg} + SS_{wg}$

This can be expressed as:

$$\sum_i \sum_j (Y_{ij} - GM)^2 \quad \sum_j (\bar{Y}_j - GM)^2 + \sum_i \sum_j (Y_{ij} - \bar{Y}_{ij})^2$$

The SS_{bg} is then partitioned into variance for each IV and the interactions between them.

In a case where there are two IVs (IV1 and IV2), the equation looks like this:

$$n_{km} \sum_k \sum_m (IV / IV2_{km} - GM)^2 = n_k \sum_k (IV1_k - GM)^2 + n_m \sum_m (IV2_m - GM)^2 +$$
$$[n_{km} \sum_k \sum_m (IV1 / IV2_{km} - GM)^2 \quad n_k \sum_k (IV1_k - GM)^2 + n_m \sum_m (IV2_m - GM)^2]$$

Therefore, the complete equation becomes:

$$\sum_j \sum_k \sum_m (Y_{jkm} - GM)^2 = n_k \sum_k (IV1_k - GM)^2 + n_m \sum_m (IV2_m - GM)^2 +$$
$$[n_{km} \sum_k \sum_m (IV1 / IV2_{km} - GM)^2 - n_k \sum_k (IV1_k - GM)^2 - n_m \sum_m (IV2_m - GM)^2]$$
$$+ \sum_j \sum_k \sum_m (Y_{jkm} - IV1 / IV2_{km})^2$$

Because in MANOVA there are multiple DVs, a column matrix (vector) of values for each DV is used. For two DVs (a and b) with n values, this can be represented:

$$Y_{i...n} = \begin{bmatrix} a1 \\ b1 \end{bmatrix} \begin{bmatrix} a2 \\ b2 \end{bmatrix} \begin{bmatrix} a3 \\ b3 \end{bmatrix} \cdots \begin{bmatrix} a_n \\ b_n \end{bmatrix}$$

Similarly, there are column matrices for IVs - one matrix for each level of every IV. Each matrix of IVs for each level is composed of means for every DV. For "n" DVs and "m" levels of each IV, this is written:

$$IVA_1 = \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV}_n \end{bmatrix} IVA_2 = \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV}_n \end{bmatrix} \ldots IVA_m \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV}_n \end{bmatrix}$$

Additional matrices are calculated for cell means averaged over the individuals in each group.

Finally, a single matrix of grand means is calculated with one value for each DV averaged across all individuals in matrix.

$$GM = \begin{bmatrix} DV_1 \\ \vdots \\ DV_n \end{bmatrix}$$

Differences are found by subtracting one matrix from another to produce new matrices. From these new matrices the error term is found by subtracting the GM matrix from each of the DV individual scores:

$(Y_{ikm}\text{-}GM)$

Next, each column matrix is multiplied by each row matrix:

$(Y_{ikm}\text{-}GM)\ (Y_{ikm}\text{-}Gm)'$

These matrices are summed over rows and groups, just as squared differences are summed in ANOVA. The result is an S matrix (also known as: "sum-of-squares and cross-products," "cross-products," or "sum-of-products" matrices.)

For a two IV, two DV examples:

$$\begin{aligned}
&\sum_j \sum_k \sum_m (Y_{jkm} - GM)(Y_{jkm} - GM)' = n_k \sum_k (IV1_k - GM)(IV1_k - GM)' + \\
&n_m \sum_m (IV2_m - GM)(IV2_m - GM)' + n_{km} \sum_k \sum_m (IV1/IV2_{km} - GM)(IV1/IV2_{km} - GM)' - \\
&n_k \sum_k (IV1_k - GM)(IV1_k - GM)' + n_m \sum_m (IV2_m - GM)(IV2_m - GM)'] + \\
&+ \sum_i \sum_k \sum_m (Y_{ikm} - IV1/IV2_{ikm})^2 (Y_{ikm} - IV1/IV2_{ikm})'
\end{aligned}$$

Determinants (variance) of the S matrices are found. Wilks' λ is the test statistic preferred for MANOVA, and is found through a ratio of the determinants:

$$\Lambda = \frac{|S_{error}|}{|S_{effect} + S_{error}|}$$

An estimate of F can be calculated through the following equations:

$$F_{approximate}(df_1, df_2) = \left(\frac{1-y}{y}\right)\left(\frac{df_2}{df_1}\right)$$

Where,

$$df_1 = p(df_{effect}) \quad df_2 = S\left[(df_{error}) - \frac{p - df_{effect} + 1}{2}\right] - \left[\frac{p(df_{effect}) - 1}{2}\right] \quad S = \sqrt{\frac{p^2(df_{effect})^2 - 4}{p^2 + (df_{effect})^2 - 5}}$$

$$y = \Lambda^{1/5} \quad p = \text{No. of DVs} \quad df_{effect} = (IV1 - 1)(IV2 - 1)...(IVn - 1) \quad df_{error} = n_{L1} * n_{L2}(n_{DV} - 1)$$

Finally, we need to measure the strength of the association. Since Wilks' λ is equal to the variance not accounted for by the combined DVs, then $(1 - \lambda)$ is the variance that is accounted for by the best linear combination of DVs.

$$\eta^2 = 1 - \Lambda$$

However, because this is summed across all DVs, it can be greater than one and therefore less useful than:

$$\eta^2 = 1 - \Lambda^{1/5}$$

Other statistics can be calculated in addition to Wilks' λ. The following is a short list of some of the popularly reported test statistics for MANOVA:

- Wilks' λ = pooled ratio of error variances to effect variance plus error variance
- This is the most commonly reported test statistic, but not always the best choice.
- Gives an exact F-statistic
- Hotelling's trace = pooled ratio of effect variance to error variance

$$T = \sum_{i=1} \lambda_i$$

- Pillai-Bartlett criterion = pooled effect variances
- Often considered most robust and powerful test statistic.
- Gives most conservative F-statistic.

$$V = \sum_{i=1}^{S} \frac{\lambda_i}{1+\lambda_i}$$

- Roy's Largest Root = largest eigen value
- Gives an upper-bound of the F-statistic.
- Disregard if none of the other test statistics are significant.