Introduction

Urban solid waste management problem is considered to be one of the most serious environmental problems particularly in developing countries. Municipalities everywhere are coping with increasing amounts of solid waste and need urgently to formulate efficient methodologies to combat the situation. In order to develop an effective waste management in any area, it is important to know the amount of waste generated and the composition of the waste stream. Many research have established that the amount of waste generated is proportional to the population. There are several other factors which affect the amount and composition of waste. These are climate, living pattern and habits, level of education, religious composition, cultural belief, social and public attitude. According to census 2011, In India total urban population reported 377 million i.e. 31.16 percent of the total population is residing in urban areas. There are 468 class I cities and fifty three metropolitan cities in India. Magnitude and density of urban population in India is increasing rapidly. The problem of municipal solid waste management has acquired alarming dimensions and required serious enquiry. The present situation of solid waste management in India, like in any other developing countries is fighting with many inadequacies like weak infrastructure, poor financial status of municipal bodies, unavailability of modern technological input, Illegal and unsafe dumping is a major problem that raises serious concern with regard to safety and quality of life. In Kanpur City the responsibility of collection & disposal of solid waste lies with Kanpur Nagar Nigam, but the efficiency of collection of solid waste is not satisfactory due to inadequate man power, funds and infrastructure facilities. Financial and institutional issues are important aspect of waste management. Large scale migration into the cities due to various socio-economic reasons and the rapid growth and increase in population have created serious environmental problems in the city. The enormous increase in solid waste generation particularly in large cities will have significant impact in terms of the land required for waste disposal.
(i) Statement of the Problem

Kanpur is the largest and very important city of Uttar Pradesh. The city is divided into six administrative zones which are further divided over 110 wards. Kanpur city covers an area of 291.78 square Kilometers which consist 34,15,058 persons (As per Projected Population 2010). There are various types of waste generation points i.e. household Institutions, commercial complexes, health care facilities centres, Industrial units, slaughter houses, animal husbandry and dairies, and waste water treatment plants. The large amount of waste, garbage generated everyday in the city of Kanpur has become serious concern for environmental policy makers and scientists. The annual waste generation increases in proportion to the increase in population and urbanization. With the rapid development and changing lifestyles in cities have also changed waste composition from mainly organic to mainly plastic, paper and packaging material that are complex in nature of storage and collection systems are becoming more sophisticated and costly as the types and sources of waste produced become more diversified and as the availability of disposal sites within the collection areas become limited insufficient and improper method of disposal of solid waste which results in scenic blights, create serious health hazard to public health, air pollution, ground water pollution and also creating excessive stress and nuisance. Waste characteristics varies significantly from city to city and from season to season and also varies with time to time. Quantities of solid wastes are just thrown in depression or around pond without having preliminary knowledge of its characteristics and its effect on health and environment. In the present study an attempt has been made to examine the nature and characteristics of waste and components of waste management i.e. waste generation, characteristics, storage, collection, transport, processing and disposal. In view of the new environmental laws and regulations imposed by the government from time to time, the local self govt. is looking forward to explore an alternative method of waste handling since the disposal of solid waste is a serious issue and challenging task in the context of ecological sustainability. There is an urgent need to develop best of alternative methods of solid waste handling and disposal problems.
(ii) Aims and objectives

The present study has certain specific research objectives these are-

1. To examine the nature of existing solid waste problem of Kanpur City and its impact on urban environment.
2. To analyze the spatial pattern of municipal solid waste generation and collection method in Kanpur City.
3. To develop cumulative score index for assessment of urban environmental conditions of Kanpur City.
4. To identify site suitability for waste disposal.
5. To undertake characterization of Municipal solid waste at disposal points.

(iii) Research Hypotheses

Few Hypotheses are put forwarded to deal with the problem. These are as follows -

1. There is a strong association between the density of population, intensity of urban land use and intensity of degradation of urban environment.
2. There is a linear relationship between the generation of solid waste and Environmental Vulnerability
3. The levels of vulnerability of environment are proportionate to the human population.
4. There is a linear relation between high intensity of solid waste generation and improper management.
5. The high proportion of uncollected waste, poor standard of transportation, storage, treatment and disposal leads to land and ground water pollution.

(iv) Data Base

The present study is based on the published and unpublished as well as primary and secondary source of data. In case of population data of 2001 has been used. Various other important information regarding total number of municipal staff and functioning strategy of Kanpur Nagar Nigam have been collected from Kanpur
Nagar Nigam office. Apart from this various other information have been collected from private company A to Z. office. Various maps like ward boundary map and open drainage map have been obtained from Kanpur Nagar Nigam office, Kanpur. Besides this various report, maps, research papers books, monographs and various other useful information published and unpublished material have been collected from different source of government agencies. An attempt has been made through random sampling which gives the basic information on solid waste generation, characterization, income information, transportation method, and collection and disposal method. In order to get various other useful information related to income, literacy, perception, awareness regarding the problem questionnaire have been designed. For this purpose out of 110 wards there are only 30 wards have been selected as sampled wards in order to represent the whole city.

(V) Research Methodology

For the purpose of vulnerability assessment of solid waste problem in the city there are ten variables have been selected these are namely relative relief, density of population, waste generation quantity, polythene generation quantity, literacy pattern, income, sweeper population ratio, sweeper road length ratio, sweeper bin ratio and length of open drain (Nala’s) in the city. The six administrative zones of Kanpur city were classified in five categories. A score of 1 to 5 were assigned to each criteria/variables. With a score of I on the criteria denoting to better condition whereas 5 is given to worst condition. Each ward have been assigned score on the basis of selected criteria and the finally cumulative score of the individual criteria for each ward/zone has been calculated on the following formulas.

$$CSW_N = \text{Cumulative Score of Individual Criteria.}$$

$$N_{W1,2,3,4,5} = \text{No. of ward assigned score}$$

$$S_{1,2,3,4,5} = \text{Assigned score for each level}$$

$$CSW_n = N_{W1} \times S_{W1} + N_{W2} \times S_{W2} + N_{W3} \times S_{W3} + N_{W4} \times S_{W4} + N_{W5} \times S_{W5}$$

The average cumulative score ($\Sigma CSW_n/N_{W1}$ $N_w = \text{No. of criteria}$) were categorized into very high, high, medium, low and very low.
1-Sampling Procedure

For the purpose of selecting sampled ward multistage stratified random sampling were adopted. There are thirty wards have been chosen for the purpose of study i.e. 5 wards from each zone five percent of household from each ward were selected. The total sampled size consisted nearly 5706 households (600 households have been selected from very high income group, 846 from high income group, 1689 from medium income group, 986 from low income group and 1585 from very low income group.

2-Interview schedule

The data have been processed by interviewing the respondents from the sampled households. Keeping in mind the objectives of the study questionnaire was designed. The first part gives focus on general observation of the ward the second part gathered information about household profile, the third part handled with information about the housing conditions, fourth part deals with information about household waste and last part handled with information about various problems associated with waste problems

3. Collection of data

Data were collected through personal interview with the help of questionnaire designed (Appendix-1) The investigator on the basis of interview schedule interviewed the selected respondents from the sampled households were visited at random at least twice to check the information provided. Researcher tried to collect all the relevant information about their household waste conditions. More than one year time was spent on data collection. After the collection of data, it was processed and tabulated in spread sheets to analyze in order to arrive at result.

4. Investigation

(i) Physical Characterization of solid waste

Characterization of solid waste have been made on monthly basis. Sampled was collected during January, 2010 to December, 2010 in order to identify physical characteristics of solid waste, About 2 kg of municipal solid waste was collected from
each of the sampling sites from inside solid waste dumps located in 30 selected wards of Kanpur city. The total quantity of solid waste thus collected was 60kg. For quantification of solid waste representative weight per unit has been assessed with the help of a spring balance and electronic weighing machine. Sample from respective location were brought to open field and have been separated into Biodegradable and Non-biodegradable category waste with their representative weight has been assessed in kg and estimated moisture content result are presented in percentage. The moisture content of solid waste for biodegradable and non-biodegradable components was determined using the following expression or equation.

\[
\text{Moisture content } \% = \frac{W_1 - W_2}{W_1} \times 100
\]

Whereas \(W_1\) = wet weight of non biodegradable or biodegradable fractions (gm)

\(W_2\) = Dry weight of non biodegradable or biodegradable fractions (gm) dried at sunlight.

(vi) ORGANIZATION OF THE WORK

Present work starts with an introduction and spread over seven chapters. Finally a brief conclusion based on findings of the research work has been discussed.

CHAPTER-I deals with conceptual framework to understand the basic concept of solid waste management, meaning and definition of solid waste management, basic issues of waste management which includes solid waste characteristics, generation aspects, nature and composition of solid waste, problem of solid waste storage, collection, method of solid waste disposal, solid waste characterization, management practices and management policies.

CHAPTER-II deals with the survey on the nature of work done by other scholars. Survey of literature plays a crucial role in research because it helps the specific research in designing the research plan on particular issue. This chapter includes on nature and characteristics of waste, review on technological aspect and review on management and planning strategies.
CHAPTER III- deals with the Geographical setting of the study area. This chapter includes, location and extent, Relief, Drainage pattern, Climatic characteristics of the study area, it also includes various demographic aspect like distribution of population, density of population, population growth, pattern of literacy, Land use pattern and transport network.

CHAPTER IV- devoted to assessment of solid waste generation problems. This chapter includes an assessment on identification and characterization of solid waste characteristics of Non biodegradable and Biodegradable waste and moisture content, estimation of waste generation and polythene generation in the study area.

CHAPTER V- presents a detailed account of assessment of solid waste collection and disposal system. It includes assessment about primary waste collection system, secondary waste collection system, problem of handling and managing of solid waste, problem of existing transport system, status of waste storage facilities, lack of dumping sites, lack of equipment and modern technologies, management and governance, political problems and waste processing and disposal mechanism.

CHAPTER VI- Explains the vulnerability assessment of urban environment. It includes zone wise analysis of risk of vulnerability through the assessment criteria of Relative relief, density of population, quantity of waste, quantity of polythene generation, pattern of literacy, sweeper population ratio, sweeper road length ratio, bin population ratio, length of open drains (Nala's) lastly cumulative view of vulnerability have been discussed with comparisons of results.

CHAPTER VII- deals with waste management strategies which includes identification of vulnerable areas for the purpose of planning, proposed strategy for spatial planning with reference to primary waste collection system, secondary waste collection system, waste transportation, disposal of solid waste, identification of landfill sites, solid waste collection routes, route and dustbin planning and financial management. Lastly summary and conclusion have been discussed.