CHAPTER 4

LITERATURE REVIEW

4.1 INTRODUCTION

The purpose of the study is to develop a framework for effective and efficient waste management practices for hotel industry. In line with the purpose, the literature review in this chapter has been presented in five areas:

1) Present situation of waste management in India.

2) Impact of waste generation on environment.

3) Emission of greenhouse gases (GHG) from waste generation.

4) Currently waste management practices in hotel industry.

5) Audit process for waste minimization.

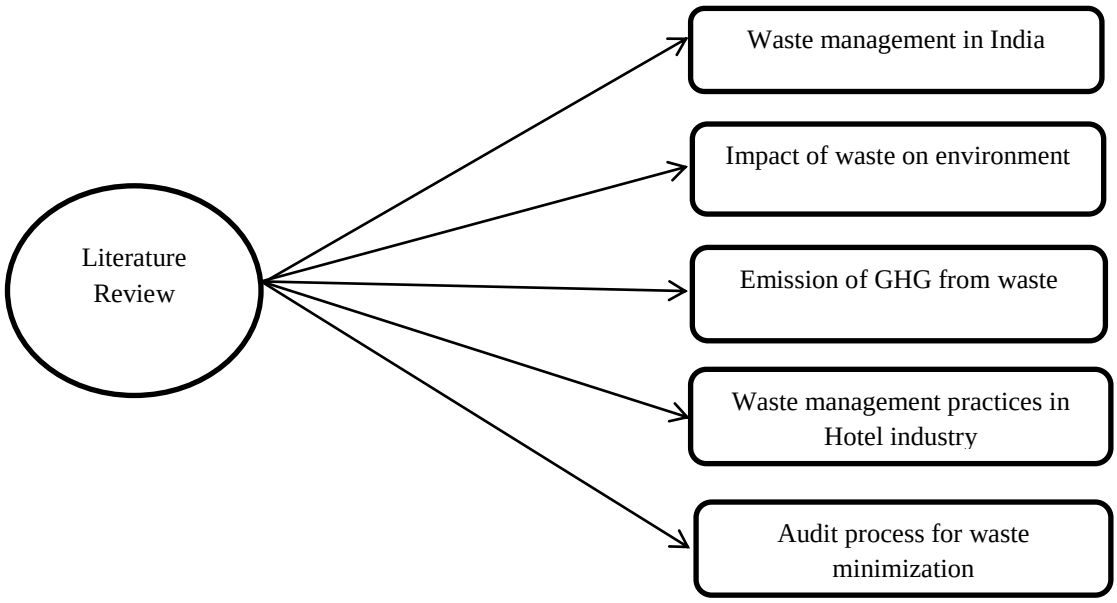

Figure 4.1: Structure of literature review

Source: Pictorial representation of literature review

4.2 PRESENT SITUATION OF WASTE MANAGEMENT IN INDIA

In the ages of modernization and industrialization there is a most common problem in today's environment [71] [72]. Pollution means change in various intrinsic properties [73] [74] and is caused mainly by human [75] [76].

One of the underlying reason for environment degradation I pollution and there could be several reasons behind [77]. These reasons could be population increase, industry growth, degradation of forest, unhygienic conditions etc. [78]. This leads to imbalance in whole ecosystem [79]. Problems such as water pollution, drainage system, waste dumping could arise out of it[80].

Waste management is one of the complex problems for entire nation [81]. Portion of organic waste is always higher in fraction that leads to problem of human and environment [82] [83]. Road side garbage from houses remains unclear because its volume is more than what the corporation can handle. Some of the useful items were taken out by Rag pickers[11][84]. The volume of waste included colonies, outlets, markets of fruits vegetables etc. (refer table 4.1).

Table 4.1: Sources and Types of Municipal Solid Waste

Sources	**Typical waste generators**	**Components of solid waste**
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, glass, metals, ashes, special wastes (bulky items, consumer electronics, batteries, oil, tires) and household hazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government center, hospitals, prisons	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Municipal services	Street cleaning, landscaping, parks, beaches, recreational areas	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational areas

Source: Adopted from United Nations Environment Programme [83] [85]

Viswanathan [85] argues that waste is increasingly becoming more problematic in nature. Most of cities and towns of any nation is highly crowded and facing problem of inadequate supply of water, solid waste and disposal area[86][87].Leachate[12]formed due to pollution causes water contamination [88 [89]. Today solid wastes are considered as one of the major

sources for pollution in the human environment. Various types of pollution are spreading all over the world, posing wide variety of health and environmental threats. The solid waste generated due to the human activities causes enormous environmental damages to the soil and water sources. Improper management of waste further creates a risk to environment and human health because of insanitary conditions. [90] [91].

India generated 229 MT of solid waste in 2001 with per capita generation of 100-500 grams [94]. The Energy and Resources Institute (TERI) says there will be growth in waste generation in India from 1-1.33% by 2047 [95].

There is 45-75% organic waste in overall production of waste. It is estimated that per capital waste from major metro rage from 0.45 – 0.6 kg per day per person [96] [97]. In a high technology industrial world, garbage is an unavoidable consequence of prosperous [98]. In terms of house hold waste can be classified as vegetables, fruits, shells, metal, plastic etc. [99]. These waste generations poses problem of contamination ground water, fire, explosion in land-fill sites[100].This turns worse when Garbage left unattended [101]. This garbage also poses problem for cities, towns due to its undesirable effect [102]. Chunk of waste disturbs ecological balance of environment as well as limited the land area of residential and other useful purposes which is required in urban area [103].

In some developed countries, recycling process is used at initial level of waste source. Later on waste vendor collects waste and returns salvage value of it [104] [105]. In India up to thrre quarter waste remains collected but there are some process like recycling, composting, to utilize that source. Memon [106] discusses the concept of ISWM and its arguments. There are some stages of the ISWM chain which include source separation, collection and transportation, transfer stations and material recovery, treatment and resource recovery and final disposal. It is suggested that 3R is integrated within ISWM. This Paper also highlights the process of developing and implementing ISWM in cities/towns. This process includes waste data and assessment of current waste management systems and development of an ISWM plan with its implementation strategy. If this process is managed separately, then it would be a costly business. Hence, joint efforts under ISWM could be efficient and effective. This is a major challenge for all cities. Implementation of ISWM is straightforward because local capacity supported by national and international initiatives, can lead to all the actions

being undertaken locally, including waste characterization and quantification, assessment of the current waste management system, targets for ISWM, identification of stakeholders and development of an ISWM plan and implementation strategy for ISWM [106].

Baldisimo [107] study of Bangkok, Jakarta and Manila, while analysing scavenging of municipal solid waste in, observed that the quantities and characteristics of solid waste produced vary from country to country and identifies the factors that influence it as the average level of income, the sources, population, social behaviour, climate, industrial production and the market for the waste materials.

Jenkins & Robin [108] in their study on American municipalities found that waste generation increased with increase in the percentage of population in the age group between 18 and 49. She also developed a model where households maximize utility, which positively depends on the consumption of goods and negatively on the quantity of recycling. The budget constraint included a disposal charge for municipal solid waste collection. The quantity of municipal solid waste generated was found to be sensitive to the price of municipal solid waste collection. Analysing data for in American municipalities, she found that a $1.00 dollar fee per 32-gallon trash bag would reduce waste generation by 15 per cent. She estimated that such a pricing system would improve social welfare by $650 million per year i.e. around $3 per person per year. The average price elasticity for municipal solid waste collection was -0.12.

Mclain[109] says that change in life-style is major contributors in generation of waste in USA. In his study, it is found that one third of waste is in form of packaging and container material. Koning[110] surveyedon countries like Brazil and Mexico had high rates of over 0.3tons/person/year and countries like Bolivia and Equador had lower rates of less than 0.1tons/person/year.

Bhattarai [111]analysed the household behaviourpattern on solid waste management in Kathmandu metropolitan city and found household size and income as the major determining factors for the total quantity of wastes generated. Salhofer [112] dealt with four different approaches to analyse waste generation rates: i) Input–output models: In these models, input of the waste generator is assessed by using production, trade and consumption data about products related to the specific waste stream; ii) Factor models: These models consider

analysing factors like income, housing types etc. 28 which describe the processes of waste generation; iii) Region specific classification iv) Single point of generation based classification and v) Macro level classification.

Ambat [113]identified the types and estimated the quantities of waste generated in each ward of Thiruvananthapuram City Corporation. It was estimated that a total of 290-300 tons of solid waste were generated in the city. The contribution of the households was 181 tons followed by markets (40 tons) and hotels and restaurants (30 tons).The medical waste was about 13 tons. The non-degradable waste like plastics, paper, metals and glasses were collected from the source or from the disposal sites by a group of rag pickers. They sell these wastes to the wholesale dealers who will transport these wastes to Salem and Coimbatore for recycling. The technology optimization study considered composting as the best method for disposing waste in Trivandrum since the degradable waste content (50%) is high in the solid waste stream. Bio-methanation was suggested for institutions, hotels and marriage halls. The important aspects of the solid waste management action plan included; a) segregation and characterization of the wastes at the source itself ; b) decentralized collection from the primary source and centralized collection from secondary sources; c) strengthening the existing informal waste collection sector d) detailed transportation network planning.

Ray [114] examined the present solid waste management scenario in the city of Ahmedabad and identified the problems of the existing systems and analysed the steps taken by the city corporation to rectify the problems.

Ambat[115] analysed the current practices of solid waste storage, the present waste management practices, the communities' perception on the existing collection and management system in Thiruvananthapuram city. The study also examined the changed attitude of the community, people's preference and willingness to cooperate and pay for an improved solid waste management practice and also identified the new initiatives at the local level for waste management. 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. It was found that 55% of the households reduce, reuse and recycle 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.

Mathew [116] examined the quantity and quality of the solid waste generated in Kottayam town. Random and cluster sampling methods were 39 used for selecting the households. The total waste generated per day was about 52.3 tons and the per capita generation was 0.62 kg/per day. It was found that the storage capacity of the community bins being inadequate. Vermicomposting was considered as the most effective method for organic wastes.

Sekher [117]analysed the process of municipal waste management in the city of Bangalore while focusing on the situation in Karnataka state. The paper considers the characteristics of municipal waste generated, the management practices involved and the role of the stakeholders in the overall process. Inadequate municipal service, unscientific disposal system, lack of civic awareness in waste management lack of a proper market for recycled waste products .etc. are found as the most important deficiencies in the waste management system.

Study on Thailand city, Chiemchaisri[118] articulates that the amount of waste generated is on basis of economic development, population and technical efficiency of recycling. It is calculated that institutional and business area can generate 67% while rest 33% from hospitality waste. The total Municipal Solid Waste (MSW) generation in Thailand increased from 11.2 million tons in 1993 to 14.3 million tons in 2002 (Fig 4.1). Moreover, the average per capita generation rate increased from 0.53 kg/capita/day in 1993 to 0.62 kg/capita/day in 2002. This clearly indicates that the quantity of the generated MSW in Thailand and the per capita generation rate are both increasing with time, pointing to the need for a sustainable approach to disposal and management [118].

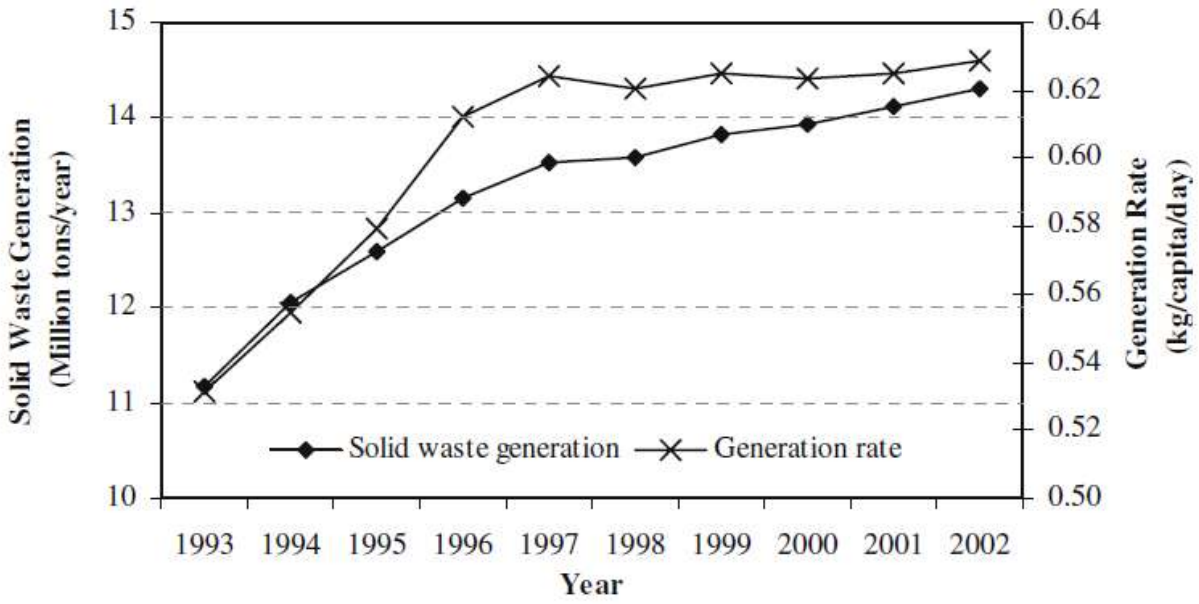

Figure 4.2: Solid waste generation and per capita waste generation

Source: Chiemchaisri et.al [118]

Bhuiyan [119] daily estimation in Dhaka is around is 3,500 tons. Out of it 400 tonnes of recyclable waste is only from informal sector. However, in one of the rigorous study conducted by JICA report [120] demonstrated that waste from domestic area is 1950 tons per day with 0.34 kg/person/day. It is projected to increase 2382 ton/day and 2817 per day in 2010-15 [120].

Growth of growth and increasing urbanization means bigger and denser cities and increased Municipal Solid Waste (MSW) generation in each city. India was generating 31.6 million tons of waste in 2001 and is currently generating 47.3 million tons, a 50% increase in one decade. It is estimated that these 366 cities will generate 161 million tons of MSW in 2041, a five-fold increase in four decades. At this rate the total urban MSW generated in 2041 would be 230 million TPY (630,000 TPD) [121].

Table 4.2: Population growth, urban waste generation and future predictions

Year	Population (Millions)	Per Capita	Total Waste generation Thousand Tons/year
2001	197.3	0.439	31.63
2011	260.1	0.498	47.30

2021	342.8	0.569	71.15
2031	451.8	0.649	107.01
2036	518.6	0.693	131.24
2041	595.4	0.741	160.96

Source: Adopted from Annepu, R.K [121]

MSW Rules 2000 mandate "landfills should always be located away from habitation clusters and other places of social, economic or environmental importance", which implies lands outside the city. Therefore, increase in MSW will have significant impacts in terms of land required for disposing the waste as it gets more difficult to site landfills [122].

Table 4.3: Area of land required for unsanitary disposal of MSW

Year	**Area of Land Occupied/Required for MSW Disposal (sq.km)**	**City Equivalents**
1947 - 2001	240	50% of Mumbai
1947 - 2011	380	90% of Chennai
1947 - 2021	590	Hyderabad
2009 - 2047	1,400	Hyderabad + Mumbai + Chennai

Source: Adopted from Annepu, R.K [121]

Study by TERI (The Energy Resources Institute, earlier Tata Energy Research Institute) in 1998, titled 'Solid Waste Management in India: options and opportunities' calculated the amount of land that was occupied by waste disposed for time period between 1947 to 1997. The study compared the waste disposal land occupied in India was in multiples of the size of a football field. Study arrived at conclusion that this land is equivalent to 71,000 football fields of solid waste, stacking up to 9 meters of height. Based on business as usual (BAU) scenario of 91% landfilling, the study estimates that waste generated in country by 2001 would have occupied 240 sq.km or an area half the size of Mumbai; waste generated by 2011 would have occupied 380 sq.km or about 220,000 football fields or 90% of Chennai [123] and [124].

There are many innovative approaches that can be used for sustainable solid waste management; especially the ones whichthe participation of public-private partnership for collection, treatment and disposal of waste [125].

4.3 IMPACT OF WASTE GENERATION ON ENVIRONMENT

The literature on environmental issues are immense, but dispersed and often concentrated on very specific problems and sometimes highly technical in nature. There are many important literatures available on environmental concern and problem [126]. A similar sentiment was expressed by Gurunanak. When he said "Air is like God, Water is Father and Earth is Mother", it is through the harmonious interaction of all these vital ingredients that the whole universe is being sustained [127].

Natural resources are sparse and their consumption is high [128] [129]. Manivasakam commended that pollution is like a tiger lurking in the bush, ready to pounce upon us at any time leading to total destruction.

Macniell[130] said that developed countries are over exploiting natural resources so for long run these resources will become limited. Therefore renewable resources should be preferred in usage. The same study also done by Roy [130][131].Donella Meadows explained the obvious causes of ecological degradation with the help of a formula known as PAT formula [132]. The formula denoted that:

$$I = P * A * T$$

Here, I is environmental impact, P is population, A is material throughput associated with Affluence, T is technology

The formula represent degradation of environment with reason of increasing population and economic growth [132]. Rapid economic growth and population boom are considered as the reasons behind environmental degradation by William Barron, he said,

"It is the only high Income place in the world that is acquiring a third world environment"[133].

Lahiry[134]revealed that globalization and industrialization are responsibe for growth of economy as well as environment degradation[134]. Varshney [135] said that population and material growth result in global warming. It is also responsible for ozone depletion and loss of biodiversity. John Bellamy foster [136] said that there are some other sources like energy,urbanization, population etc. are responsible for increasing carbon footprint

One important problem that required specific mention among environment issues is the degrading urban environment. Kamath[137]commended urbanisation is growing at a tremendous pace leading to "a world of agglomerations, megapolis piled on megapolis". He also extend that as the urban man satisfies his needs and desires, he spoils the environment. So urbanisation is considered as a menace to the survival of homosapiens and a crime against humanity.

Angoni[138] and [139] gave same result that pollution of air, generation of waste, noise pollution, and contaminated land are seen in developed nations. Serageldin and John Martin Brown [140] talked about above factors are responsible for waste generation.

Trivedi and Gurdeep Raj said that in urban areas shops, factories and institutions can generate high amount of waste that disturb the urban life [141][142]. Raghupathi[143] classified overall urban environmental problem in three like micro level, meso level and macro level.

The main concerns in urban city are degrading environment condition because of open dumping, run off ground water etc. [143].According to Benjamin [144] from past year only life style is responsible in village as well as in city. But in recent decade various industrialization make solid waste one of the challenging problems.

Venketaswaran[145] established relationship between problem of waste and urbanization; she said that development of human life from cave to community is only with help of urbanization. This development also supports waste generation. McCarthy [146] found that this local concern is becoming global with increase in its intensity. Mills [147] classified problem of waste in two forms: first is improper diseconomy and second issue is local inefficiency.

Nath and Hens [148]said that environmental pollution is from all three sources air water and land. Also suggest that managing solid waste can also control the pollution of above areas.

Generation of solid waste and related services like collection, transportation, processing and final disposal of waste are important both in terms of health of the public and environment [149]. Solid waste is a complex mixture of different substances. The potential health effects of such solid waste are a subject of research [150]. Although most of the studies focused on the health of the people, particularly those living near a waste disposal site or landfill, improper management of solid waste has considerable adverse effects on the health of staff and also the community associated with dealing solid wastes. In some cases, improper waste management can lead to the spread of infectious diseases. Some of the specific case studies, given below, discuss wet waste that decomposes and releases a bad odour, owing to unhygienic conditions; thereby leading to health problems.

Extensive literature shows the adverse ill effect of waste on environment and human health provided by National Solid Waste Association of India (NSWAI) in table below 4.4.

Table 4.4: Adverse effects of wastes reach landfill and open dump sites

Broad categories of Environmental or health hazard	**Specific deleterious affect**
Environmental pollution	Air quality, water quality, land use.
Spread of Communicable diseases	Diarrhoea, gastro- intestinal diseases, respiratory infection, skin diseases, Jaundice, trachoma, Eosinophilia, etc.
Occurrence of Non communicable diseases	Poisoning, hearing defects, dust allergies.
Possibility of Injury	Occupational injury by sharps, needles, glasses, metals, wood, violence etc.
Disturbance to aesthetics	Odour, visibility, dust etc.
Birth defects and reproductive disorder	Low birth rate, congenital malformations
Effects on community due to MSW solid waste incineration	Release of toxic, carcinogenic and mutagenic substances, increase in incidence of laryngeal, liver, lung cancers.
Potential risk to workers population	Risk of musculoskeletal problems, exposure to bio-aerosols and volatile compound resulting in respiratory, gastrointestinal and skin problems.

Increase in vector population	Putrefying waste is the breeding ground for rodents, insects and mosquitoes. Which are the vectors/career of many diseases such as malaria, dengue etc.

Source: Municipal solid waste (MSW) Manual [65] and Rushton [17]

There are many illustrations that shows the reality of impact of waste on human health and environment like examples of staff and community engaged in waste handling, waste dumping nearby village etc.

Illustration 4.3.1: Health Status of staff and community associated with MSW Management in Kolkata [150]

A study was conducted with a sample size of 732 adult individuals (male 466, female 266), recording the health of rag pickers, staff and community associated with waste dealing by qualified medical practitioners at the site of garbage dump, landfill or at the nearest office of the Kolkata Municipal cooperation (KMC). Questionnaire was developed containing habit, economic condition, family size, duration of work etc. On the basis of respiratory symptoms and illness determination broadly two groups are categorized:

- Upper respiratory symptoms (URS) including sinusitis, running or stuffy nose, sore throat, common cold and fever.
- Lower respiratory symptoms (LRS) including dry cough, cough with phlegm, wheezing, chest discomfort or pain.

Analysis of result shows that UR symptoms were found around 82% in worker and around 93% I rag pickers. Similarly fraction of LR symptom was much higher in conservancy staff and rag pickers. Impairment of lung function was found in 71% of the conservancy workers and 84% of rag pickers in contrast to 57% in control population. Thus the case study concludes that there is a direct correlation between the health of workers/rag pickers and their exposure to solid waste.

Illustration 4.3.2: Municipal solid waste management in cities - issues of basic rights of people of surrounding a village and alternatives, Villappilsala, Thriuvananthapuram City [151]

Villappilsala is a place with natural beauty but due to commencement of waste disposal plant for treating the municipal solid waste, the environment is polluted due to the arrival of garbage from the city and fresh water aquifers are contaminated due to dumping of inorganic waste which cannot be treated using the technology available. When the factory started functioning, there have been reports that it has been causing environmental and health problems to the local community likes Water contamination, health issues of clean air to breathe, Problem of insect vectors and other litters or sanitation problems.

Illustration 4.3.3: Case study on Health Hazard associated with waste [152]

Elliott [152] has reported the health impact of solid waste inUnited Kingdom. They observed that significantly elevated risks and several defects, including neural tube defects, hypospadias and epispadias, abdominal wall defects and surgical correction of gastroschisis and exomphalos in those people that reside in the vicinity of landfill site, usage of incinerator in "waste to energy" approach is suspected to cause cancer problems like laryngeal, lung cancers, childhood cancers, leukaemias, soft-tissue sarcoma and non-Hodgkin's lymphoma.

Vasanthi [153] found that disposal of solid waste likely to contaminate ground water. Waste that is dumped without any treatment contaminates portable water. Leachate from these wastes contain in form of Nitrogen, potassium, calcium, iron etc. when the leachate mix with water it affect whole community.

In India, there arenumber of reports about leachate problem. In one study in Chennai shows that 4,800 tons of waste generate and reached at 6,000 tons by the year 2010 [153].

Once the waste prevention program executed further it is converted to integrated waste management that is feasible for large amount of waste material. The sanitary landfill is alos play important role for waste storage.

Direct dumping of untreated waste in rivers, seas, and lakes result in the accumulation of toxic substances. These substances thenenter in the food chain through the plants and animals that feed on it. In addition, improper disposal of solid waste may produce bad odours weaning away beauty of nearby areas.

4.4 EMISSION OF GREENHOUSE GASES (GHG) FROM WASTE GENERATION

For last few years importance of global warming increases day by day that contains high amount of hazardous gases that resulting increase in temperature. IPCC [154] reports reveals that Methane[13] is important and hazardous gas in GHG. It is also estimated that it is twenty time dangerous than carbon dioxide [154]. Overall Methane emission accounts 3-19% all over the world only from landfill site [154]. The estimation has been made from mere calculation using national statistics on waste generation. In many countries, especially the developing economies of the world, the available data on waste generation are not consistent, leading to a large uncertainty in the estimates.

Nowadays, global warming and Ozone depletion is main issue for international level. Most of reports like intergovernmental Panel on Climate Change (IPCC) expected that it would increase from 1– 6 degree centigrade [155]. Between the year 1984 and 2004, CO2 increases by 43% with annual increase of 1.8% [156]. In Hong Kong, the total amount of GHG emissions in 2007 was about 46,700 kilotons of CO2-equivalent (CO2-e), or 6.7 tonnes per capita [157], which is comparable to the statistic (6.26 tonnes per capita) announced by the International Energy Agency [158]. Though being lower than those recorded in developed countries such as the United States (19.1), Australia (18.75), Singapore (9.8), Japan (9.68) and the United Kingdom (8.6), this level was still higher than that of the whole world (4.38).

In India, most of the solid wastes are disposed of by landfilling in low-lying areas located in and around the urban centres. The total methane emissions from Indian landfills carried out by National Environmental Engineering Research Institute (NEERI), worked out to be 0.334 (Tera-gram) Tg year during 1990–1991 [159]. The present paper, therefore, makes an attempt to estimate the realistic values of methane emission from municipal solid waste (MSW) landfills, by carrying out extensive investigations both from field and available national statistics.

Landfill gases are created from anaerobic decomposition of waste like methane and carbon dioxide. A wide range of gas production rate is estimated between 0.187 and 0.424 m^3 kg wet wastes or between 0.009 and 0.02 m^3kg [160]. Gases produced are not managed properly and

affect negative on human health and environment. Amount of land fill gas is based on waste type, region, and local factors. Apart from this, other conditions like moisture content, PH value [161] [162]. Municipal solid wastes in developed and developing countries have common of food waste. Here summer and winter season also affect land fill gases.

The estimation of methane gas emission from landfills has been consistently investigated by various researchers across the globe. Mostly, attempts were directed to estimate the landfill gas (LFG) for its extraction and utilisation as a renewable source of energy. These methodologies could be very well explored for their use in the estimation of GHG emissions. It could be seen that there is a need for reliable and consistent data on MSW for estimation of LFG when solid waste is disposed of in a controlled manner. In India, where such conditions do not prevail, it may be necessary to adopt empirical relationship coupled with scientific logic. The LFG could be better estimated by using the first-order decay (FOD) in two phases. In the first phase, the rate of generation keeps on increasing till the peak is reached; thereafter, it keeps on declining till the material is stabilised [164].

As a case study of urban areas in Southeast Asian countries, methane emissions from the waste landfill sites in Hanoi, Vietnam, were investigated based on a document survey and field measurements with the study aimed at being applicable to other Asian countries [165]. To estimate methane emissions from waste landfills, the streams of organic waste before landfilling were estimated in Hanoi from a document search, exploratory investigations, and interviews with persons in charge. Furthermore, to obtain the regional-specific behaviour of methane emission from waste landfills, field measurements were executed in both operating and closed waste landfills in Hanoi [165].The methane emission potential, E, from degradable organic carbon (DOC, tons) was estimated using the following equation:

$$E = MCF \cdot DOC \cdot DOC \cdot F \cdot F\ 16/12$$

Where:MCF- is the methane correction factor, 1.0; DOCF- is the dissimilated DOC content, 0.5; F- Is the methane content in landfill gas (LFG)

Furthermore, the annual change in the methane emission from the waste landfill was assumed to decrease with first-order decay (FOD) method [165]. IPCC suggest that construction of

building also helps in emission reduction [166]. Carbon audit is one of the main sources of GHGand it is reduced for construction of building [167]. There are many guidelines for carbon audit having different base and methodologies. There are many examples of calculating carbon emission like modelling approach that is sued for planning of energy and reducing carbon footprint. Most of studies estimate this emission on basis of depth field data [168] [169][170].

In tourist destinations like Singapore and Hong Kong in which hotels are energy efficient buildings [171] [172] [173] that predicts amount of emission reduces with help of construction of building[174].Emissions are major problems in India have grown steadily over time. There was a time when it was not such a big problem though today it is huge in intensity. The waste sector includes solid, biological, incineration and open waste along with andwas responsible for roughly 124 million TCO2e of emissions in 2005, or 6.7% of total Indian emissions. The average contribution of the waste sector in Asia is high than the world average. Indian emissions from waste are not very high and lower compared to many other countries. The rate in waste over last decade was 1.8% which represents 31% overall growth from the waste sector [175] and is increasing at fast pace.

Table 4.5: Growth in GHG emission from waste

Country	**1990**	**2005**	**Change**	**Avg. Annual growth**	**Total growth**
Canada	20.2	27.2	7	2.00%	34.60%
India	94.4	123.8	29.4	1.80%	31.10%
Indonesia	27.9	34.5	6.6	1.40%	23.50%
Brazil	34.6	42.8	8.1	1.40%	23.40%
Australia	10.3	12	1.7	1.00%	16.70%

* CH4 (MtCO2e)

Source: Climate analysis indicator tool (CAIT), version 6.0, Washington D.C [175]

In contrast, during the same period, many developed countries greatly reduced emissions from waste, largely due to improved landfill gas recovery technologies, recycling programs, and integrated waste management practices at the municipal level. For example, the U.S. reduced emissions from the waste sector by 0.9% annually, for an overall reduction of 13.1%.

European nations saw even greater reductions. In Germany for example emissions from waste decreased by 64.4% over the last 15 years [175].

Most of researched on issue of estimation of emission for different years [176], [177],[178], [179], [180], [181],[182], [183],[184] and [185]. India has submitted the Initial National Communication (INC) to UNFCCC in June 2004 including inventory of CO2, methane and N2O using many domestic emission factors [186]. The reporting year is 1994 and this inventory is used as a benchmark for greenhouse gases (GHGs) for the current study.

Above research estimates that emission for years 1985–2005. The report covered main GHGs gases like carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF6). In 2007 recorded GHG quantity of 1727.71 MT of CO2 equivalents consisting of 1221.76 MT of CO2 release along with 20.56 MT of CH4 and 0.24 MT of N2O [187].

Another study by Garg [188]found 10% methane from all sectors. They estimated that CO2, CH4 AND N2O was 778.00, 18.00, and 0.30Tg (Teragram; 1 Tg ¼ 1 million tonnes) respectively. In India these are growing at 6.3% (CO2), 1.2% (CH4), and 3.3% (N2O), respectively. This is based upon real data depicting current status. Other report [189] depicts trend in GHG in India for 1985–2005. Details of the findings of the study are illustrated in figure below:

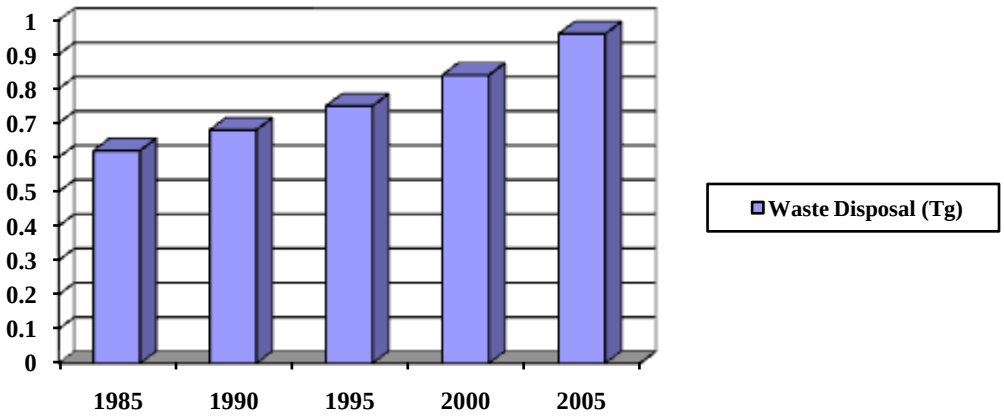

Figure 4.3: Methane (CH4) emissions from various sources in Tg-CH4

Source: Adapted from Garg. A. et al. [189]

According to author [188], methane and nitrous oxide are the two main gases which emit from waste. From table 4.3, the methane (CH4) emission rate was 0.62 Tg in 1985 and after 20 year in 2005 it reached 0.96 Tg means increase at 2.2 percent compound annual growth rate (CAGR).

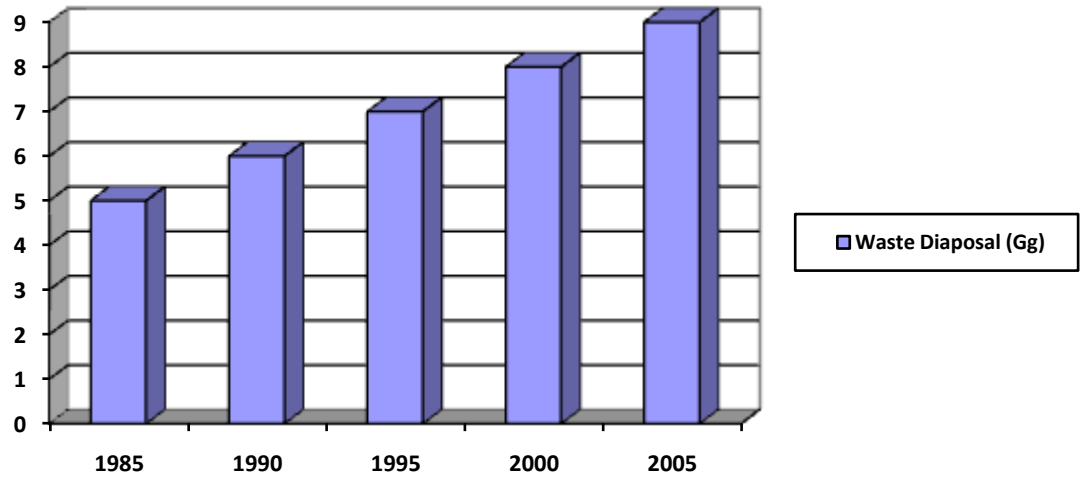

Figure 4.4: Nitrous oxide (N2O) emissions from various sources in Gg-N2O

Source: Adapted from Garg. A. et al. [189]

In the same manner the rate of nitrous oxide (N2O) was 5 Gg in 1985 and it increased to 9 Gg in 2005 with growth rate of 2.8 percent CAGR. Thus it can be said that this growth trend needs to be checked before it creates major imbalance in the environment, causing health related problems to human being.

Report by INCCA[190]compared the trend values between the dominant sectors of societies. The GHG emission from 4 major sectors for year 1994-2007 showed that tremendous changes in their compound annual growth rate as mentioned in table 4.6 [190].

Table 4.6: Comparison of GHG emissions by different sectors

Sector	**Year 1994**	**Year 2007**	**CAGR (%)**
Electricity	355.03(28.4%)	719.30(37.8%)	5.6
Transport	80.28 (6.4%)	142.04(7.5%)	4.5

Agriculture	344.48(27.6%)	334.41(17.6%)	-0.2
Waste	23.23(1.9%)	57.73(3.0%)	7.3

Source: Adapted from INCCA, India: Greenhouse Gas Emissions [190]

The estimation of greenhouse gases (GHG) is based on the first order decay model which is an improvement over the mass balance approach used in earlier reports, and is based on an exponential factor that describes the fraction of degradable material which degrades into CH4 each year. One key input in the model is the amount of degradable organic matter (DDOCm) in waste [190]. It is represented as:

$$DDOCm = W * DOC * DOCf * MCF$$

Here DDOCm= is decomposed mass in mGg
W = deposited waste inGg
DOC = degradable organic carbon in the year of deposition, fraction, Gg C/Gg waste
DOCt = fraction of DOC that can decompose (fraction)
MCF = CH4 correction factor for aerobic decomposition in the year of deposition (fraction)

CH4 generated in a year is estimated by amount and decomposition [190]. Thus methane generated in a year can be calculated as:

Methane generated in year T

$$CH4 = DDOCmdecopomT * F * 16/12$$

Where,
F = Fraction of CH4 by volume
16/12 = molecular weight ratio, CH4/C

$$CH4\ Emitted\ T = (\Sigma\ CH4\ generated\ X, T - RT)\ x\ (1 - OXT)$$

Where,
RT = recovered CH4 in year T, Gg

OXT = oxidation factor in year T, (fraction)

On an average for all cities waste generation rate is 0.55

A study byHoornweg [191] estimates emission of CH4 for year 1995 – 2025 that shows emission in India increases at least 6 times for past 1995 year. It shows that India is 2nd highest emitter of methane.

Table 4.7: Waste generation and methane emissions from waste disposal sites (1995-2025)

	1995 Data			2025 Projection		
Country	**Urban MSW generation rate (kg/cap/day)**	**Methane Emission (kg/year)**	**Methane Emission (kg/cap/year)**	**Urban MSW generation rate (kg/cap/day)**	**Methane Emission (kg/year)**	**Methane Emission (kg/cap/year)**
China	0.79	898.52	2.35	0.9	4075.12	4.93
India	0.46	474.55	1.92	0.7	2774.92	5.37
Indonesia	0.76	457.49	6.52	1	1581.74	9.05
Thailand	1.1	165.33	9.44	1.5	424.39	13.58
Malaysia	0.81	68.91	6.08	1.4	281.11	11.09
Bangladesh	0.49	38.66	1.46	0.6	243.69	3.29
Vietnam	0.55	31.76	1.96	0.7	189.87	4.6
Myanmar	0.45	18.46	1.61	0.6	106.41	3.94
Cambodia	0.69	2.67	1.64	0.8	25.5	3.5

Source: Urban MSW generation rate as cited by Hoornweg et al. [191]

According to the Wilco[192], hotel industry consumes large amount of energy resources so recommendation is to adopt energy efficient practices. Cheung [193] shows that in Langham Place Hotel, Mongkok, Hong Kong effectively reduce carbon footprint by designing energy efficient building.They reduce about 1900 ton of waste by using various green practices. In another study, Gossling [194]said that consumption pattern is changed due to tourism industry that affect food as well as drink industry. To reduce volume of waste, Kirk [195]suggest that green purchasing policy, minimizes waste, proper waste disposal are three main strategies of waste management. Bohdanowicz[196]said that Hilton hotel in Europe changes varous

operational activity and training to staff help to manage their waste. Similarly, Liqin[197] in his paper "Relative analysis of the carbon footprint of the high-stared hotels during operation" assessed 6 hotels and suggested some strategies to reduce emission. For example use of mixed grain, new vegetable and cooked food in their kitchen along with saving energy by adopting low carbon consumption equipment.

Rossello[198]studied area in Balearic Islands. He found that for last 50 years energy is used highly as most of hotel arras consumes high electricity. This results heavy cost which can be reduced to gain monetary value [199]. Another study byHorobin[200]suggests that implementing environment strategies along with awareness of environment motivate staff and their worker.

Methane is produced in large quantity in landfills, as a consequence of the degradation of organic matter under anaerobic conditions [201]. Landfills often accept waste over a 20 - 30 years period, so waste in a landfill may be undergoing several phases of decomposition. This means that older waste in one area might be in a different phase of decomposition than more recently buried waste in another area [202].

The GHG emission from landfill areas in India has come into focus in last ten to twelve years and there is more number of studies on methane emission from landfill areas. In one of the study an attempt has been made to calculate the methane flux from three landfill areas of Delhi i.e., Gazipur landfill area (GLA), Okhla Landfill area (OLA) and Bhalswa landfill area (BLA), which is one of the highly populated city in India. This study has also reviewed the research work done on GHG emission from landfill areas in India.

Table 4.8: Present scenario of landfill sites in Delhi

Name	Location	Area (hectares)	Start year	Waste received (Tpd)	Zones supplying waste
Bhalswa	North Delhi	21.06	1993	2200	Civil Lines, Karol Bagh, Rohini, Narela, Najafgarh and West
Gazipur	East Delhi	29.16	1984	2000	Shahdara (South), Shahdara (North),

					City, SadarPaharganj, and NDMC
Okhla	South Delhi	16.2	1994	1200	Central, Najafgarh, South and Cantonment Board

Source: Adopted from ManjuRawat, AL. Ramanathan [203]

The total methane flux calculated for three landfill areas of Delhi (Gazipur, Bhalswa and Okhla) is as 0.54 Gg/year, which is relatively in higher side as compare to the total methane emission estimated from MSW landfill sites in India i.e., from 0.30 - 1.8 Tg per year. This could be that Delhi's MSW generation is higher than the other cities [203].

4.5 CURRENT STATUS OF WASTE MANAGEMENT PRACTICES IN HOTEL INDUSTRY

There are many research papers and report that articulate the importance of waste management in hotel industry for environment concern. Hotel industries consist of restaurant, bars etc. made up of large number of small operation and in each operation consumes relatively small amount of energy, water, food, paper and other resources but with the consumption of energy it add a small amount of pollution too in terms of smoke, smell, noise and chemical pollutants [204]. However, the impact of these operations together has a significance effect on global resources. Kirk [204] reviewed some of the development within the industry of responsible environment management and investigate attitude of manager in hotel industry in Edinburg. Author suggests that there is a need for global policy making and target setting for CFC (chlorofluorocarbons) emission and the adaptation of environmental policies must come from Top. Without a commitment at the highest level of the company, it is unlikely that ideas developed throughout the organization will flourish. He said that environmental management is also important to the individual company not only on their financial performance but also on their responsibility towards the environment. One of the main objectives of the author is to find "Do guest want green hotels?" and for this there has been many survey in USA suggest positive consumer attitude towards environment [204].

Waste management and its disposal is main concern today. Various authors suggest that proper hierarchy of source to destination [204].Authors believe that tourism is one of the main factors that affect the environment with the help of hotel industry [205[206] [207][208] A complication is found in the tourism industry that it can affect current market image of hotel industry. Attractive sides are facing these problems of waste generation that create worse scenario [209] [210] [211].

Hotel industry in a sense of protecting environment acts as a tool. Todaythere is competition in hotel industry regarding growth and sustainability [212] [213]. In competitive scenario advantage like waste management is a most important tool for sustainability [214] [215]. Hutchinson [216]tried to link environmental commitment to their actual performance.

Small hotel are focussed on customer preference but neglect environment management that further affect in negative term [217] [218] [219]. With recycling pollution can be controlled along with cost and increase overall profit [220] [221] [222] [223]. Eco-efficient products also help to reduce negative effect and create positive impact on consumption [224] [225]. Waste management is win-win situation for company and stakeholders [226].

Cortes [227] in his paper examined the implementation of environment management as a competitive tool.

An increasing number of international hotel brands are reporting their sustainability activities. Some global hotel chains have begun to provide reports using such measurements as carbon, energy, water, and waste. The companies issuing such reports include Accor, Hyatt, IHG, Marriott, Starwood, and Wyndham. Among other firms, Goldman Sachs has noted these reports and has provided sustainability ratings for hotel brands [228]. The City of New York has also created a database of hotels' reports of water use, Energy Star scores, and greenhouse gas emissions. In short, the more comparable the reports, the stronger the competitive factor will be among hotels, particularly given the interest from customers, such as groups and meeting organizers, who want to use the hotels' reports to calculate their own carbon footprint [228]. Measuring sustainability continues to be a challenge, since there are so many variables in hotel operation, even with such standards as Energy Star and ISO 14001. More to the point, given themany certifications, one question is whether guests even pay attention to

certifications. Research has found benefits for hotels certified with ISO 14001, but there remains a research gap linking that certification with client's evaluations [228].

Many small and large hotels have low intrest in recycling because they think its expensive and time consuming [229]. In 2002, the Welsh Assembly Government (WAG) [230] developed model for England to consider recycling and composting in their waste stream [231] [232]. Cummings [233] developed a model for hotel industry that includes commitment of waste minimization, eco policy, reuse-recycle for overall solid waste management [233] [234]. Hayward [235]identified customers' attitudes towards hotel and environment has positively changedon basis of waste management.

Taleb[236] gave a model hotel in Egypt helping them to use recycling for various benefits. Many countries use principle of "pay as you throw" to reduce waste [237]. In US authorities are strict to implement laws for business activities [238] [239]. Apotheker[238]showed 13 methods for dealing with recycling with help of local government [240] [241] [242] [243].

Maineri[244]shows that customers are not interested in green practices found that customers so this cost will bear by hotels. Maclaren[241] and Horobin[242] told impediments for recycling in hotels. Most literature showed that food waste are sent o piggeries farm for feeding but can be easily compostable [245] [246] [247].

There are various cases in literature talk about SWM model in hotel industry. (see Figure 4.4). The model considers four main steps to reach zero waste [248].

Step 1: Gain hotel commitment to solid waste management (SWM)

Step 2: Select a waste carrier

Step 3: Undertake a waste audit

Step 4: Implement an SWM programme based on the waste hierarchy

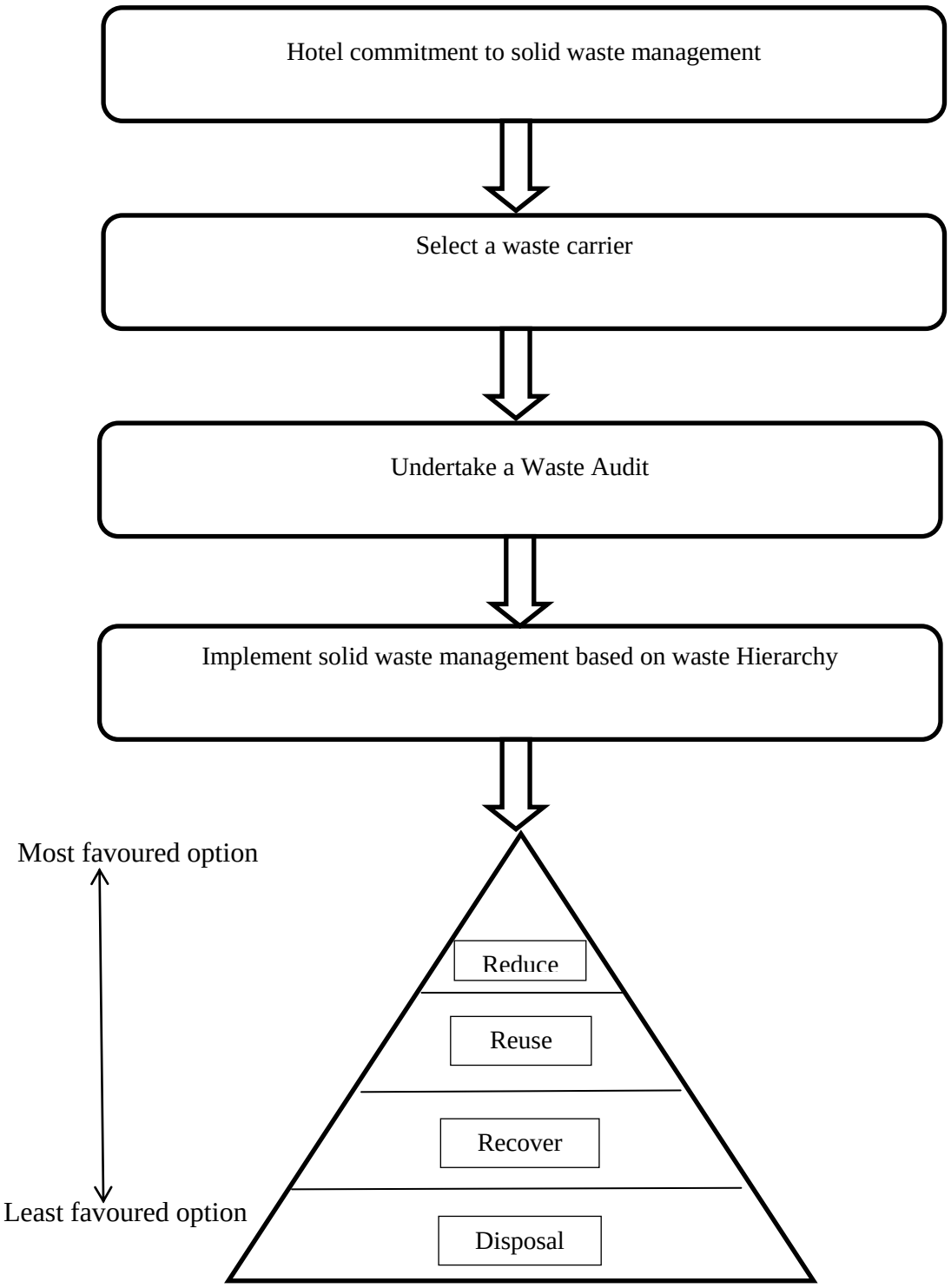

Figure 4.5: Best practice model of SWM in small hotels

Source: Adapted from Radwan., H.R.I et al. [248]

Steger [249] defined an Environment Management System must be implemented in order to protect environment Almost all hotels have implemented their in-house EMS or used efforts on protecting the environment in hotels with varying degrees of intensity in the past few decades [250]. Environment Management Act (EMA) like ISO 14000 that supports auditing program to know type of waste generated [251]. Companies must be certified with ISO 14001 to show environment credentials [252] [253]. With help of environment strategy it increase market value of hotels along with increasing efficiency [254] [255] [256].

Many negative impact are associate with hotel industry causing pollution of air, water and land [257] [258] [259][260][261] [262]. Environmental management is referred to as “the processes and practices introduced by an organization for reducing, eliminating and ideally, preventing negative environmental impacts arising from its undertaking [260][261] [263].

In one of the pioneering study by Penny [264] suggest that environment management is facilitating Tool in Macao, China. The Environmental Technology Best Practice Programme (ETBPP) defines wastes minimisation as using ``management methods for systematically reducing emissions to land, water and air" [265]. The concept is a relatively straightforward one; by using materials carefully so as to reduce the generation of wastes, pollution is reduced, resources are conserved and hence charges for disposal are minimised [266]. A wastes minimisation programme for a given company would cover; raw material and ingredient use, product loss, water consumption and effluent generation, paper and packaging, factory and office consumables, energy consumption, all other solid, liquid and gaseous wastes, and wasted effort [265].

Waste minimisation is recognised by the UK Government as the best way to minimize the adverse effect of wastes on the environment [267] [268]. It is also clear that in the industrial and commercial sectors businesses must face the full cost implications of the wastes they produce in order to encourage them to reduce waste production [267]. Certain sections of the food and drink industry have well established waste minimisation programmes. In a cross industry survey [268], it was found that 95% of the brewing industry operated wastes minimisation programmes (95% also operated recycling programmes) compared with only around 25% of the food and retailing sector.

In April 1996, the ETBPP established a distinct programme for the hotel and restaurants having fooding and drinking facilities to stimulate the uptake of wastes minimisation, as it was perceived to be too slow in this sector. There is a range of benefits for a company that operates a wastes minimisation programme, these include environmental and legal, as well as financial. One of the major factor is financial that influences the implementation of a wastes minimisation programme [269].

Research within the industry should be intensified to ratify the efficiency in the treatment of waste and to minimise waste in operational activities. This will decrease environmental loadings as a consequence of better integrated waste management [270]. It is necessary to segregate the solid waste from the liquid waste for potential reuse of both fractions [271]. Merely disposing of wastes lost useful substances and these residual products can be transferred into business products [272]. An integrated approach to wastes minimisation can take many forms, for example the proper design and application of process controllers is essential for minimising both operating costs and out-of-specification waste products [273] [274].

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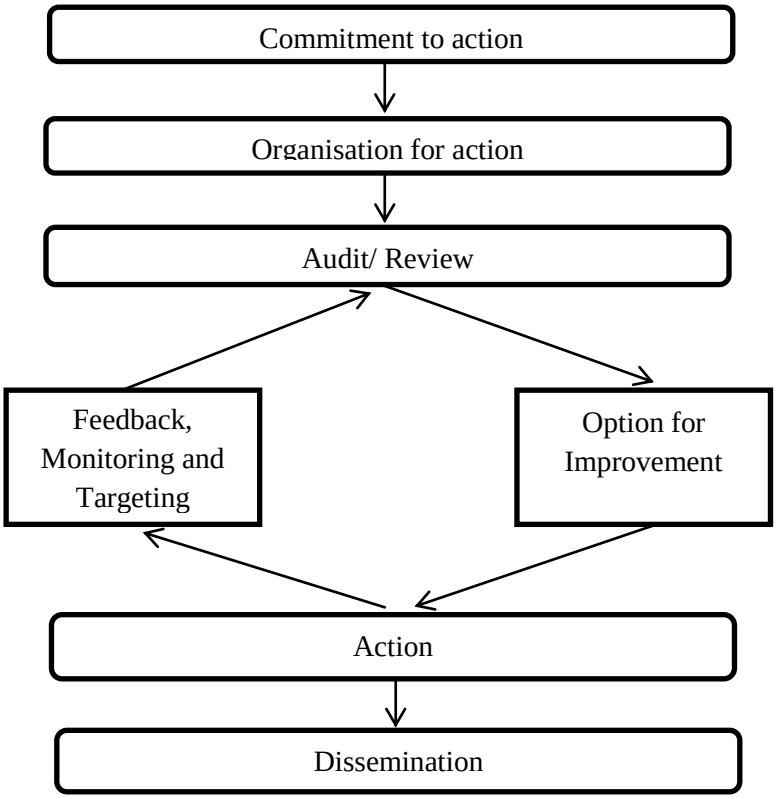

Figure 4.6: Wastes minimisation programme/methodology

Source: Adopted from Bates et.al [274]

Author think that change in waste handling technologies and methodologies has led to many industrial food processing wastes that were once considered as having no economic value, now being reused and recycled [274].

4.6 AUDIT PROCESS FOR WASTE MINIMIZATION

The growing importance of environmental awareness among people regarding limited natural resources. Many useful researches reviewed the typical types of waste produced by hotel industry. For example, [275] [276] [277] indicated that entire hotel can generated glass, paper, steal, cardboard, food etc. According toSherman [278] and Ibrahim [279] food waste negatively affect the environment in many ways.
Earlier Axler[275] researched the estimation of the volume of waste in hotel industry [280]. Potts [281] observed that large property could accumulate eight tons of waste per day and approximately 60 per cent of the waste is recyclable in nature [282] [280].

Hotel owner can playing an important role in reducing wastage of plastic, paper, bottles, batteries, bathroom amenities etc. [283]. Execution of government legislation indicated by Hasek[284], for waste reduction in hotel industry [285] [286]. On theother hand, [287] [288]shows that laws and regulations for hotel industry to dispose of waste materials in a scientific manner.

A waste audit is most structured process to quantify the amount of waste generation along with its categorization. Waste audit comprised of systematic collection of available information.As per report of APPCB [289] waste reduction opportunity quantify the problem and suggesting it as operational level in any business.

Basically auditing of waste, conducted by APPCB [289] has classified into four steps:

Step 1: Planning and organization

Step 2: Assessment

Step 3: Feasibility analysis

Step 4: Implementation

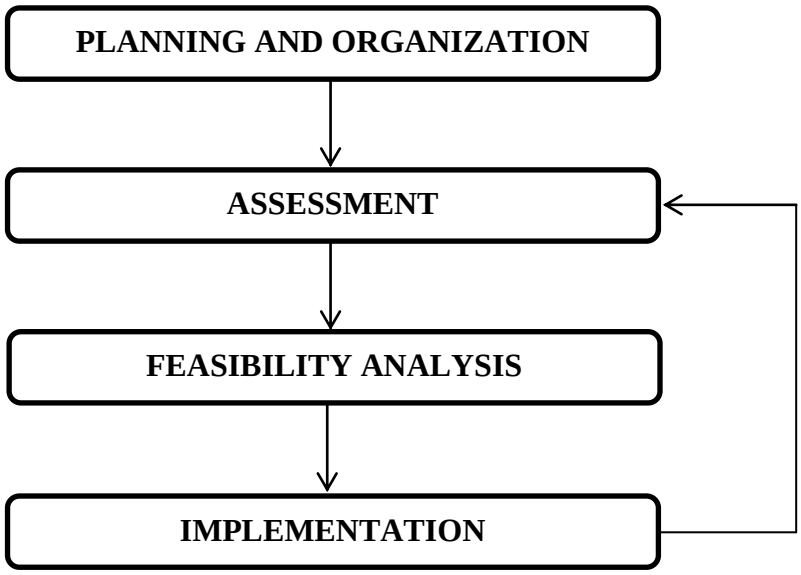

Figure 4.7: Waste audit programme- overview

Source: Andhra Pradesh Pollution Control Board (APPCB)[289]

EPA [290] inthe year 1990 suggesting that the industrial Waste Management Policy must be implemented for reduction of waste. The policy adopts the following preference of options [290]:

• Wastereduction and avoidance
• Waste recycling and reuse
• Wasteproperly treatment
• Waste disposal

There are many example of waste audit; it depends on type of waste generated and its area. For example audit sheet of school waste auditing could take following form:

Area of Auditing _____ Number of bags collected _____
Name of monitor _____
Position (e.g. pupil, teacher etc.) _____
Start date(s) of Waste Check _____ Finish Date(s) _____

Using the table below, list the items you have found, their weights and the percentage this is of the total. Remember to include any small items:

Table 4.9: Waste audit check in school

Material type	**Weight**	**Percentage of total**
Office papers		
Mixed papers		
Cardboards		
Food and drinks cans		
Plastic		
Glasses		
Organic wastage		

Source:Adopted from Antrim- Waste audit [291]

Solana Recycler[292] emphasis on compelling need for the hotel waste auditing. Indicate the example of a hotel in which recycling practices of mixed office paper, corrugated cardboard, mixed paper, green garden waste, glass etc. are implemented

Table 4.10: Waste Characterization

Waste Category	**Percentage**	**Type of Waste**	**Percentage**
Paper	35%	cardboards	20%
		newspapers	10%
		mixed papers	5%
Plastic	22%	PET bottle	3%
		HDPE container	5%
		Polystyrene & other	14%
Glass	1%	CA Redemption glas	1%
		other glasses	
Metal	4%	steel can	4%
		aluminum can	
		other metal	
Organics	17%	Food Waste	18%
Textiles	6%	linens, towels, etc.	7%
Other Waste	15%	All type	16%
Total			**100%**

Source:Waste characteristics adopted from Solana Recyclers [292]

4.7 CUSTOMER PREFERENCE FOR GREEN HOTEL

There are numbers of research paper enlighten the concept of waste management or green practises in hotels, it is proved by various author that green practices based hotels are highly preferred by customer. Most of the case studies on hotel like Scandic and Hyatt Regency, have shown the success of ‘green’ practices in hotels[328] [329]. Attitude of hotelier ion some of the studies are in positive sense [330] [331]. Choi [332] did a research on hotelier attitude regarding ‘green’ practices in the USA restaurant industry to know the relationship between employee and its customer [333].

Peattie[334] identify the waste management practices as a profitability tool in hotel. According to Foster [335], the hotel industry must be environment friendly for customer satisfaction. Consumers are willing to purchase various environmentally-friendly products to take participation in environment saving [336] [337] [338].

In one of the research by Manaktola[339] shows a positive relationship between the customer attitude and behaviour towards green practices in the hotel.