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Sustainable Integrated Solid Waste Management in the Trans-Himalayan Accommodation Sector

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Abstract

The purpose of this study was to characterize the waste generation profile of the tourist destinations in the Indian Trans-Himalayan region of Ladakh which are facing acute solid waste pollution. Leh town is a hub of touristic activity in Ladakh. However, tourist accommodation sector is a major contributor to solid waste generation of the town and poses severe challenge for the sustainable development of the region. Hitherto very few scientific studies have been undertaken to analyze the magnitude of waste generation from accommodation industry in order to visualize anthropogenic pressure on the destination under investigation. Therefore, the present research work was a scientific attempt to estimate the magnitude, composition, quantity and temporal trends in solid waste generation in the tourist accommodation of the town and suggest a suitable model for its proper management. Direct Waste Analysis Method has been used and 10% representative sample selected through random sampling technique. The results reveal that tourist accommodation sector generates about 1093.69 annually out of which 60% can be diverted for composting and 30% for recycling to relieve burden on the destination. The study depicts that there is huge potential of resource recovery for the waste streams of accommodation industry in the area. The data set generated through this pilot study could be indispensable for envisaging an integrated solid waste management plan for of the town.

Keywords - Trans-Himalayas, Leh, Ladakh, Integrated, Waste, Management, Composting, Recycling

Introduction

Solid waste is being regarded as the worst type of pollution because it is discernible unlike other types of pollutions and frequently occurring in every passing second (CPCB, 2000; UN, 2000, Obirih, et al., 2002). Moreover, urbanization has increased over space and time with more than half the world's population now living in urban centers (Tacoli, 2012), and by 2050, urban dwellers probably will account for 86% of

the population in developed countries and for 64% of the population in developing countries (UNDP, 2012). Thus, solid waste management has become a burgeoning problem for international, national and local governments as it is the single largest budget item for the majority of urban centers (UN, 2010; Habitat, 1994; World Bank, 2012). Besides the crude open dumping is a common method of waste disposal, which poses a huge potential and real threat to the public health and especially to the quality of environment. Thus, the magnitude of solid waste generation is so high, that the existing levels of technology, manpower and finance are falling short to handle it properly (Al-Yousfi, 2004; Ahmed and Ali, 2004; Tacoli, 2012), which, so far, has exceeded the earth's natural decomposition and absorption ability (Smith, 2004).

The mountainous regions face additional challenges of solid waste management on account of inadequate methods to handle it, which has serious cascading effects on its fragile environment (Jain and Kuniyal, 1994). Besides, the seasonal tourist influx compounds the problem considerably because of the fact that an enormous quantity of waste is generated within a shorter period of time (Wani and Shah, 2013). The International Hotel Environment Initiative (IHEI, 2002) reports that every customer can produce 1 kg of solid waste a day in a typical hotel, which accumulates into thousands of tonnes annually, much of which goes to landfill sites without any suitable treatment. The improper management of waste can contribute to the occurrence of global problems, e.g. global warming, ozone layer depletion and climate change (Mensah, 2005). Once the waste material is buried in a landfill, it releases CH_4, which often contributes to air pollution and adversely impacts upon human health and the environment. The biodegrading process of waste also causes the formation of leachate, which has the potential to pollute underground water (Becklake, 1991; CPCB, 2000; UN, 2000). In this regard, the mechanism of integrated solid waste management tries to minimize the quantum of waste disposal through methods like, inter alia, reducing, reusing, recycling, recovering, composting, and incineration, etc. (Medina, 2003). It has been used in efforts to ensure environmental purity and sustainable management of resources (Cairnes, 1991; Kreutzmann, 2001; IHEI, 2002).

Study area

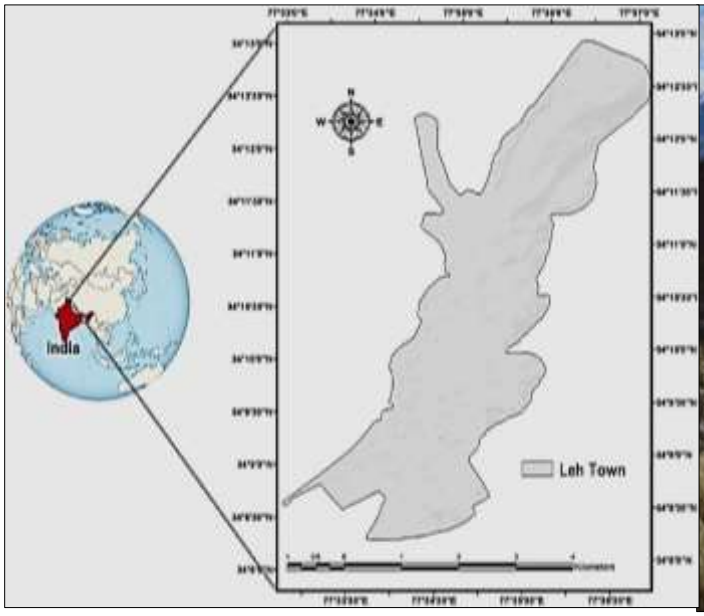

Figure I: Location Map of the Study Area

Figure II: View of Leh Town

The present study was carried out in Leh Town of Ladakh, in India. Historically, the town used to be an important stopover for the historical Trans-Himalayan Silk Route (Rizvi, 1995). The town is located at an altitude of 3500 meters above sea level on the right banks of Indus River. Though the region is basically a climatic desert (Hussain, 2000, Shah, 2013), harsh climatic conditions and topography have posed severe checks on the agriculture and other basic activities (Sagwal, 1991). However, over the years, tourism has been gaining ground and opening new vistas for Ladakhis, and in fact more so than other Himalayan tourist destinations (Alexander, 2005).The total population of the town is 3.8 million (2011, census) and people mainly are Buddhists. The region,when viewed from a hydrological point of view, is a source of some of the subcontinent's major waterways like the Indus river system, therefore environmental management in the region is of vital importance for the long lasting growth and development of the subcontinent. Strategically the area is also very politically volatile owing the international boundaries with Pakistan and China.

Significance of the study

The Ladakh region is one of the most popular tourist destinations of South Asia and also one of the most fragile ecological areas of the Trans-Himalayan region and it is vital to the sustainability of the Indian subcontinent (IPCC, 2001). The Ladakh region contributes a large amount of perennial water supply to the Indus river system which is the main source of drinking water, irrigation, hydropower generation and tourism development. Tourism businesses have brought new waves of development to Leh, Ladakh, by creating enormous job opportunities and, therefore, have been instrumental in trickling down developmental socio-economic waves to this relatively backward region.

Over the years anthropogenic pressure has slowly begun to impact negatively on the Ladakh region; manifested in the form of glacial recession, scarcity of water resources, water pollution and cloud bursts. However, the most threatening and discernible pollution in the Trans-Himalayan region is improper solid waste disposal (Alexander, 2005). Thus, there is every possibility that environs and socio-economic quality of life will become severely affected on account of what is improper environmental planning. Besides, only a few studies have been carried out regarding the solid waste dimensions in these Trans-Himalayan towns so far. However, for developing and implementing integrated solid waste management a comprehensive data base regarding the quantity and quality of material generated is very crucial (Gidarakos, et al., 2005). Against the above backdrop, the present study is a scientific attempt to analyze magnitude, composition characteristics and seasonal variation of solid waste generation for the tourist accommodation sector of the town and for the formulation of a suitable coping strategy for it.

Research design

The Base map for this study was generated from Ward maps supplied by the Leh municipality and was Georeferenced with SIO Topo Sheet of 1971 bearing number 52 F/12, in ESRI's ArcGIS 9.2.2 software. The study has been undertaken to understand the solid waste management system in Trans-Himalayan urban tourist centers in order to explore the alternatives and opportunities to achieve higher levels of sustainability. The data has been collected using a variety of methods so as to seek to gain a better understanding of the challenges, opportunities and alternatives. The present study is mainly based on both primary and secondary data. Data collection methods include literature review, sample survey and observations. The data regarding tourist accommodation units has been acquired from the Department of Tourism, Leh. There are many methods for quantifying and characterizing solid waste stream; including direct waste analysis, material flow analysis, survey analysis and empirical analysis and each method has certain capabilities and limitations (Chi, 2005). The present study used Direct Waste Analysis, the scientific and most commonly used method of the waste estimation and analysis (Maclaven Yu, et al, 1995). The methods make direct examination of the waste generation sources, characteristics such as

weight and composition (Byer, et. al, 2009). To measure each fraction of waste accurately, the researchers tried to group waste generated from different source in three broad categories, i.e. compostable, recyclable and miscellaneous wastes as shown in the table I. The classification scheme of solid waste was developed from the cutting edge research work conducted by researchers like Chi, (2005), Kessler, (SE2008), Byer, et al. (2009), Thanh, et al. (2011), Chandrappa, et al. (2012), Parandeh and Khanjani (2012), Oyelola, and Babatunde, (2013), Sanaa, et al. (2014) in the different parts of world.

Table I: Classification of solid waste

Waste Category	Waste Item
Compostable	Fruite
	Food
	Vegetable
	Garden clippings
Recyclable	Metal
	Glass
	Paper
	Rubber
	Plastics
Miscellaneous	Non-Recyclable Plastics
	Non-Recyclable Paper
	Textile
	Wood
	Sharps
	Bones
	Ash and Dust

Therefore, for the estimation of solid waste generated from tourist accommodation units, the researchers employed a random sampling technique to select the sample. Subsequently 41 hotels including guest houses out of the total of 405 units were selected as a representative sample that accounts about 10% of the total population. The sampling was done during summer season in 2014, 2015, 2016 and 2017 respectively. For the ease of the waste estimation, polythene bags of 50 kg capacity to sample hotels and guest houses. The waste estimation was conducted early in the morning before it was disposed of for dumping, and the process was repeated for seven consecutive days for each sample. For the purpose of sorting and estimation of solid waste, *Safai Karamcharies* (Cleaners) were hired from the concerned Municipality, which made it possible to determine the composition of the waste by weighing each item of solid waste stream like fruit waste, leftover food, vegetable waste, paper, plastics etc. using weighing scale. It is one of the widely used methods for waste characterization for site specific sampling via sorting and weighing waste by category (Staley and Barlaz, 2009).

Details of each item of waste stream were recorded and the magnitude of solid waste generation was expressed in kg/room/day. As a result, figures were adjusted to daily solid waste generation. In order to work out the seasonal variation in the amount of solid waste generation, the researchers employed other indicators like monthly room occupancy levels of tourist accommodation sector. Hotel room occupancy has been used to measures the tourist demand to a particular destination at any given time. The occupancy calculation is a simple division, and means the number of rooms available for sale is divided into the number of rooms sold or occupied by customers. The hotel occupancy can be computed for one night, one month or one year. It is generally expressed in percentages (Vallen and Vallen, 2013).

Formula to work out room occupancy levels in tourist accommodation

$$\text{Room occupancy} = \frac{\text{Number of rooms sold or occupied}}{\text{Total number of rooms}} \times 100$$

Results and discussion

Magnitude of waste generation in tourist accommodation

The hotels and guest houses are becoming important landmarks of the urban landscape of Ladakh particularly in Leh town, where the accommodation sector comprises of 405 units with 4105 rooms. On an average, tourist accommodation of Leh town generates about 5.11 metric tonnes of waste/day during the peak tourist season from April to September, with a per capita waste generation of 1.87 kgs/day/room. The tourist accommodation of the town mainly consists of budget hotels and guest houses. It is reported that if small budget full service tourist accommodations generate waste between 1.2-1.6 kgs per room/day, this is considered a satisfactory limit (WWF-UK and IBLF2005; Bal and Taleb, 2011). The magnitude of solid waste generation in the tourist accommodation of Leh town is 1.8 kgs per room/day which is significantly higher. The higher rate of waste generation in the tourist accommodation of Leh town is attributed to the fact that it has well developed tourist accommodation, restaurant facilities and it is also is a main center of tourist attractions. Moreover, during summer season, tourist flow is so high that it out numbers local population of the entire Leh district (Wani, 2016). As result hotel room occupancy is significantly higher.

Table II: Magnitude of waste generation in tourist accommodation

Number of accommodation units	Number of rooms	Per capita waste generation per day/room	Mean monthly room occupancy	Average daily waste generation in metric tonnes in tourist season
405	4105	1.87	66.50	5.11

Source: Field survey

Levels of room occupancy and magnitude of waste generation in tourist accommodation

As per the table II it is clear that the room occupancy levels increases dramatically during the summer season and reaches at the peak level during the month of July, because the best time to visit this wonder land is from April to the ending September. However during winter months particularly in December, January and February weather is very chilly and snowfall is common phenomena. Temperature often plunges below freezing point and Ladakh remains cut off from the rest of the world that is why room occupancy remains generally at a low ebb during unfavourable winter months.

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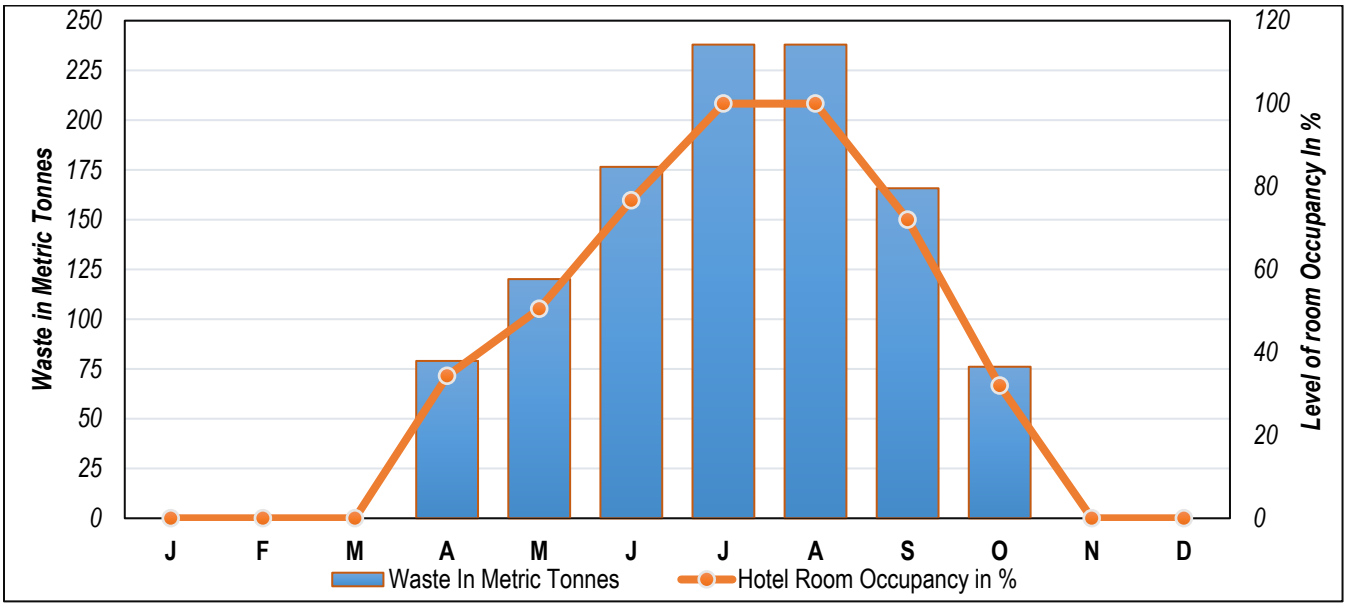
Table III: Levels of room occupancy and seasonal variation of waste generation in tourist accommodation units

Month	J	F	M	A	M	J	J	A	S	O	N	D
Hotel room occupancy in %	0.0	0.0	0.0	34.33	50.50	76.67	100.0	100.0	72.00	32.00	0.0	0.0
Waste In metric tonnes	0.0	0.0	0.0	79.06	120.17	176.56	237.97	237.97	165.81	76.15	0.0	0.0

Source: Field survey

Fig. III: Levels of room occupancy and seasonal variation of waste generation tourist accommodation units



Source: Field survey

The table III and fig. III shows solid waste generation from the tourist accommodation sector of the town is subject to significant the seasonal variations. It is clear that during the winter months i.e. October, November, December, January and February there is no waste generation because during this season there is chilly weather in the entire region of Ladakh and the mercury plunges to well below freezing point. However, during the summer season, waste generation reaches a climax because of the huge volume of tourist arrivals, which aggravates anthropogenic pressure on the environment. Similarly there is a rapid upward swing in the waste generation in tourist accommodation up to the month of July i.e. about 237.97 metric tonnes of solid waste. Because the accommodation sector experience maximum room occupancy levels. It can be further noticed that waste generation experiences decline with respect to the onset of the cold season in the region.

Gidarakos and Ntzamilis, (2006), and also Wani, and Shah (2013) reported that tourist areas experience prominent variation in the amount of solid waste generation with respect to the change of season. Therefore we can safely conclude that higher the level of room occupancy higher is rate of solid waste generation and vice versa. Such a statement is also proven by (Wani and Shah 2013; Peterson 2013), in their respective studies. Moreover Leh town is used as base camp by visitors to explore the entire

Ladakh region, as a result huge amounts of waste are generated in the tourist accommodation of Leh town.

Table IV: Quantity and composition of solid waste generation in tourist accommodation of Leh Town

Material category	Items	Waste In metric tonnes	%age of weight
Compostable waste	Fruite	85.09	7.78
	Food	374.04	34.2
	Vegetable	248.16	22.69
	Garden Waste	13.34	1.22
Recyclable	Metal	25.05	2.29
	Glass	114.95	10.51
	Paper	56.87	5.2
	Plastics	40.90	3.74
Miscellaneous	Non-Recyclable Material	6.78	0.62
	Others	128.51	11.75
	Total	1093.69	100.00

Source: Field survey

The base of successful planning for a waste management programme depends up on the availability of reliable information about the quantity (Gidarakos*et al.,* 2005). Effective waste management through municipal solid waste composition studies is important for numerous reasons, including the need to estimate material recovery potential, to identify sources of waste generation, to facilitate design of processing equipment, to estimate physical and chemical properties of the waste (Parissakis *et al.,* 1992; Wani and shah, 2013). From the table above it is evident that about 60% of the total waste generated from the accommodation sector is compostable in nature, including wastage of fruit, food, vegetable and garden clippings etc. A study by Van Waning, (2010) confirmed that in the accommodation sector about 60.3% of the total waste generated is organic in nature. Among the compostable items food is dominant which constitute about 34.2 % of the total weight generated. The discarded edible items of the hospitality sector constitute the food waste in particular (Okazaki, *et al.*, 2008; Pirani and Arafat 2014), this uneaten food can be given as donations to the needy people or it can be used as valuable feed for animals and poultry.

Among the recyclable material, glass is the most dominant source of waste, which accounts for about 10.51% of the waste of the accommodation sector. Researchers like (Winter and Azimi 1996; Parfitt, *et al.,* 2013), highlighted that in hotel waste streams, more than about 7% of the weight of solid waste is constituted of glass. Paper waste comprising of cardboard, print paper and newspaper constitute around about 5% weight of total waste Shanklin, *et al.*, (1991) Alexander, (2002) and also Evans, (2008) have come to the conclusion that in the hotel industry, plastics waste constitutes about 6.7% and paper waste constitutes approximately 20% of the total weight of the solid waste generated in the hotel industry. Among the miscellaneous waste category items, charcoal, ash and dust contents are the major constituents of the waste stream. This is because in the low budget hotels, water is being boiled with coal and fire-wood. Such types of waste comprise about 11.75% of the total weight stream of the tourist accommodation in Leh town.

The table IV and fig. III show that the content of organic waste or compostable waste is quite high in the waste stream of tourist accommodation. However among compostable items, food waste is the highest contributing item i.e. Kargil town produces about 19.89 metric tonnes and while Leh town produces about 374 metric tonnes annually. The second largest portion came from vegetable waste, which amounted to about 16.26 metric tonnes in Kargil and 248.16 metric tonnes in Leh town. Among the recyclable wastes,

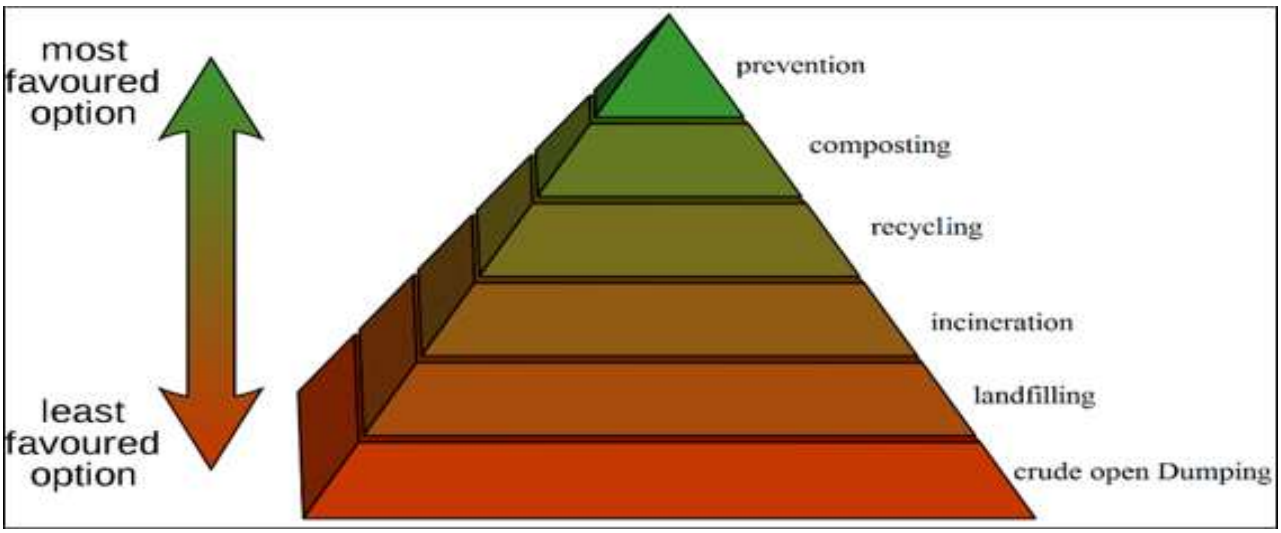
glass constitutes highest quantity i.e. 14.95 metric tonnes in the waste stream, and this is because elite groups of domestic and also foreign tourists are accustomed to consuming wine and beer which results in the generation of huge quantities of glass. Moreover there is an easy availability of wine and beer in the town which results in the generation of a huge quantity of glass.

Sustainable integrated solid waste management plan for tourist accommodation units of Leh Town

It is a holistic approach to deal with issues of management of solid waste in an environmentally sustainable and economically feasible and socially acceptable manner. It requires an integration of various processes associated with solid waste management planning process like prevention, minimization, compositing, recycling, incarnation, design, construction and operation of landfills etc. It has been observed that no single method can tackle the solid waste menace in isolation. Therefore all the methods have to work together in order to ensure proper solid waste management by evaluating the local geo-environmental and socio-economic conditions of the area (Tchobanoglous *et al.,* 1993).Integrated solid waste management is a comprehensive waste prevention, recycling, composting, and disposal program to optimize and enhance efficiency of waste management within urban areas (UNEP, 1996, 2002), and can be implemented in all types of waste management including solid, liquid and gas (USEPA, 2006).

Therefore, the basis of successful planning for an integrated waste management programme depends upon reliable information about the quantity, the type of material being generated and an understanding of about how much of that material can be prevented, captured and recycled (Parissakis*et al.,* 1992; Shah and Wani 2012). Figure 6.1 is widely used by waste management researchers to show the methods associated with integrated solid waste and environmental sustainability associated with each approach, depicted by green and red colours i.e. apex of the pyramid represents the best method and bottom represents the least favorable method. Therefore we have tried to generalize these methods of ISWM onto the data set of table 6.1 which shows the category-wise quantity of solid waste generation.

Fig IV: Integrated solid waste management hierarchy



Source: www.romero-waste.co.uk

A perusal of table IV provides essential data sets which are a prerequisite for envisaging the successful planning for the integrated solid waste management in Leh town, keeping in view the environmental suitability and sustainability requirements. The waste disposal options on the basis of environmental sustainability are listed below.

1) Prevention
2) Composting
3) Recycling
4) Incineration
5) Landfill
6) Open dumping

Prevention

Waste prevention is a strategy that involves the reduction of volume or toxicity of the wastes before it is sent for disposal, or mixes with the general waste stream. It is considered the best approach to solid waste management as it eliminates waste generation in the first place, thus eliminating the need for recycling, composting and disposal. These benefits make waste prevention the highest priority for the effective management of solid waste for Leh town owing to the previously described fragile geo-environmental setup. Leh town is the only town in Jammu and Kashmir where there is to some extents a ban on polythene carrying bags with the full cooperation from the local community, which is a smart example of pollution prevention in the region. However the tourism industry is rapidly developing in Leh, in order to cater for tourist flows, huge amounts of packed material are imported into the area resulting in the generation of a huge amount of hazardous materials like polythene and plastics. Therefore, keeping in view the environmental impacts of packing material of goods it is better to develop and use the local resources to replace the packed goods i.e. it is better to develop dairy farming as the region has huge potential for it. Moreover, it helps in reducing the dependence on packed milk and by-products of milk. Such kinds of smart initiatives will likely reduce the potential of unnecessary waste generation and help in solving the problem of ever-increasing volumes of plastics and polythene in the town.

Potential for the composting

Composting though an old traditional method is still an effective method to increase nutrients in soils from organic wastes (Drescher and Zurbrugg, 2006). It is a process in which waste is broken down biologically under controlled conditions so that the end product can be used for the agriculture and horticulture as an effective eco-friendly fertilizer (Webster, 2000).Composting reduces the formation of leachate and methane formation, decreases volume of the waste, and also kills pathogens (Bandara, *et al.,* 1999).It also reduces the chances of unwanted weed germination in agricultural fields (Jakobsen, 1995).It has been adopted by many municipalities all over the world as a viable method of waste management (Otten, 2001;Taiwo, 2011). With an increasing interest in organic agriculture, the production of compost is simultaneously also gaining popularity because of its positive effect on biological, physical and chemical characteristics ofsoil (Iglesias-Jimenez and Alvarez, 1993).It is an odour free process normally taking between three and six months depending on the how the wastes are handled and the period can be reduced by turning over the material regularly. This process can be commercially undertaken or even done at home using common agricultural equipment such as manure-spreaders and spades which have been effective in moving and turning the compost pile for centuries now (Fedrikea*et al.,* 1989).

The organic waste including fruit, food, vegetables and garden clippings have high potential for resource recovery in the form of high quality compost (Hoorweg, *et al.,* 1999). Leh town generates about 720.63metric tonnes of compostable solid waste annually which account for 66% of the total solid waste generation of the tourist accommodation enterprises in the town. Apart from preventing waste entering into dumpsites, composting process can enhance the fertility effectively because the soils of the Ladakh are coarse and generally highly deficient in the organic matter thus rendering them minimal capability for moisture retention (Bisht, 2008). Compost can increase the humus content, moisture retaining capacity and fertility of the soils. Therefore, composting has promising prospects for the Ladakh because it can help in developing the horticulture and agriculture with the negative least impact on the fragile ecosystem.

Potential for recycling

Fig. V: The researcher gathering information from scavengers at Leh dumpsite

Recycling is one the most environmentally conscious and cost effective methods of waste disposal (Nas and Jaffe, 2004). Recycling of waste can subsequently reduce the quantity of waste reaching dumpsite and landfills. Recycling not only improves waste management process but also brings economic benefit to those involved in it. There is presently no recycling unit for waste in Leh, Ladakh. However like other parts of India, the waste scavengers in the town were observed recovering valuable recycling items like bottles, glass and metal etc. as shown in the fig 6.4. They earn about Rs. 200-300 per day from the material recovered from the solid waste stream. It is clear from the table that about 237.77 metric tonnes accounting about 22% of the total annual waste stream of tourist accommodation, including items like glass, bottles, metal containers, cardboard and paper etc. can be potentially recycled. The main benefits of this informal recycling which is presently going on in the town are desperately needed employment generation, the reduction of collection and disposal costs, conservation of natural resources and the provision of raw materials at comparatively low costs. Thus, it means a huge amount of solid waste can be diverted for the recycling process. These materials can be used in various industrial units as raw materials for making the new product at relatively lower costs like for example, glass making units, metal smelting, paper and cardboard factories and tile industries .

Incineration

Incineration is another option for waste reduction and disposal, as far as the integrated sustainable solid waste management is concerned. In this process the solid waste is burned under controlled burning at

extremely high temperatures often as high as about 600° C. Table 3 Shows about 1241.17 metric tonnes in Leh town are of miscellaneous category because of low market value. However, among these miscellaneous waste items, wood , non-recyclable paper and low grade plastics, textile and bones, can be diverted for incineration plant disposal. The waste can then be burned at a very high temperature and the resultant heat energy is covered into electric energy (Jain, *et al,* 2014). Waste-to-energy incineration is presently used in some of the metropolitan cities of India and it helps greatly to reduce the volume of the waste that must otherwise be land-filled (Jain, *et al,* 2014). It also decreases gas and smoke emissions, however, there are some problems associated with waste to energy incineration as it contributes to the concentration of greenhouse gas emission and suspended particulate matter (SPM) in the atmosphere. The residues released by incineration method particularly SPM contain high levels of heavy metals i.e. cadmium, mercury and lead (USEPA, 2006) which are all very harmful to humans and the environment in general. Nevertheless, this method can ensure sustainable environmental management in general for Ladakh and meet the growing demand of electricity in hospitality sector of Leh town in particular.

Land-filling

Land-filling involves the controlled disposal of waste on land with little or no pre-treatment. It is one of the simplest and normally the cheapest method for disposing of waste (Taylor and Allen, 2003) and it is widely practiced in developing countries. According to recent estimates, solid waste contributes about one-fifth of global anthropogenic methane emissions (IEA, 2005) and methane (CH_4) is the second major contributing factor to climate change and global warning, after carbon dioxide ($CO_{2)}$ (Hansen and Sato, 2001).

Land-filling is a method of disposing of waste in a smallest practical area and reducing its volume by compaction and covering it with a layer of soil at regular intervals (Robinson, 1986). The successful operation of several sites all over the developed world has highlighted the precautions to be taken and factors to be considered while designing and operating a sanitary landfill (CPCB, 2000). Presently there is no land-filling process followed by the Leh municipality. However primitive open dumping is practiced, which poses a plethora of threats to the environment and public health. The dumping sites have become breeding grounds for flies and stray dogs. These dumping site have been selected randomly without taking any environmental and socioeconomic factors into consideration. The open dumping has been linked to many harmful health effects, including skin and eye infections, respiratory problems, vector-borne diseases such as diarrhoea, dysentery, typhoid, hepatitis, cholera, malaria and exposure to heavy-metal poisoning (UNEP, 2011). There is an urgent need to develop proper scientific sanitary landfills at appropriate places so that waste can be properly disposed of, without threating the environmental sustainability of the area.

Conclusion

Ladakh is northern most part of the India is not only strategically important also from the environmental point of view, the region is very fragile. Over the years the Ladakh has emerged as an important touristic destination in north India and Leh town acts as the 'center of gravity', because tourist use it as a base camp for the exploration of the vast region of Ladakh. However due rapid anthropogenic pressure on account of increases in urban populations, enormous seasonal tourist inflows, ever-increasing hospitality industry operations and an influx of a huge migratory labour force during summer season, these generate huge amounts of waste. Therefore, in order to deter environmental degradation caused by the improper treatment of solid waste which is not only discernable pollution but also its contribution to an intensification of other types of pollution like surface and ground water contamination, air pollution which results in the emitting of huge amounts of methane GH_4 into the air, also causing traffic jamming and also damaging

the aesthetic appeal of what must be a sustainable tourist destination. The existing practices of solid waste management adopted therein are improper and there is also a lack of segregation of waste at the source. The problem is further compounded by the fact that during peak tourist seasons, waste is deposited on streets, in streams and vacant areas, thereby making solid waste management and handling very complex. The improper waste management provides a congenital environment to stray dogs and flies which is a cause of concern for safety of locals in general, and tourists in particular.

The study has successfully generated a data base pertaining to composition, quantity and seasonal variation of solid waste generation in the tourist accommodation of the town. Such types of data are a prerequisite for devising effective planning measures for the needed effective integrated waste management. The information has been fitted to propose a practical model for solid waste management considering the options presented in hierarchy on the basis of environmental suitability. The options presented in the model can be implemented to enhance environmental sustainability by considering the potentiality of the prevention, recycling and composting in relation to the benefit to other socioeconomic activates like horticulture, agriculture particularly vegetable growing and employment generation via recycling.

The study has found that more than 54% of solid waste is compostable in nature, which can be composted locally at low cost, and then used in agriculture as a cheap and effective fertilizer. Similarly about 20% of solid waste can be diverted for recycling which can be used as cheaper raw materials in small industrial units like tile-making, paper and even the cardboard industry. The proposed framework is expected to reduce the potential negative impacts of improper waste on the surrounding environment and improve socio-comic conditions of the town . Finally, it is worthwhile to mention that the data base and the results of this study are expected to be used by local municipalities, the Department of Tourism, and Planning , the Ladakh Autonomous Hill Development Council (LAHDC) and NGOs for devising various planning and developmental strategies. From an academic point of view, it is a pioneering attempt to understand the nature of solid waste management in the Trans-Himalayan towns of India. Therefore this data base and literature have very good inputs for the student community for various multidisciplinary academic purposes. The study can be a platform for the researchers to carry out further research on various issues of sustainable tourism development in the Trans Himalayan region cold deserts of India.

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References

Ahmed, S. A. & Ali, M. (2004). Partnerships for solid waste management in developing countries: linking theories to realities. *Habitat international*, 28(3), 467-479.

Alegre, J. & Cladera, M. (2006). Repeat visitation in mature sun and sand holiday destinations. *Journal of Travel Research*, 44(3): 288-297.

Alexander, A. (2005). Leh old town, Ladakh: a participatory approach to urban conservation, community-based upgrading and capacity-building. *International Tibet Heritage Fund* http/www.tibetheritage.fund.org.

Al-Yousfi, A. B. (2004). Sound environmental management of solid waste-the landfill bioreactor. *United Nations Environmental Programmed-Regional Office for West Asia*.

Arbulu, I., Lozano, J., & Rey-Maquieira, J. (2013). Municipal solid waste generation in mature destinations: An IPAT-type model for Mallorca. *EconomíaAgrariayRecursosNaturales-Agricultural and Resource Economics*, 13(1): 69-93.

Ball, S. & TalebAbou M. (2011) Benchmarking Waste Disposal in the Egyptian Hotel Industry *Tourism and Hospitality Research* 11 (1): 1–18

Becklake, S. (1991). Green issues thinking for the future waste disposal and recycling. *Aladdin Books Ltd.*

Bisht, R. (2008). Agriculture in Ladakh: Continuity And Change, Report Prepared For Guyrja: TATA-LAHDC- Development Support Programme, Funded By The Jamsetji Tata Trust, Mumbai

BSR. (2014). Analysis of U.S. food waste among food manufacturers, retailers, and restaurants, *Prepared for the Food Waste Reduction Alliance*: *Http*www.bsr.org24 (5) pp. 465-472.

Byer, P.H., Hoang, C.P, Nguyen, T.T., Chopra, S., Maclaren, V. & Haight, M. (2006). Household, Hotel and market waste audits for composting in Vietnam and Laos. Waste Management and Research, 24 (5) 465-472.

Cairns, J. (1991): The need for integrated environmental systems management. In: *Integrated Environmental Management*. Cairns J, Crawford TV (eds), Lewis Publishers

Central Pollution Control Board (CPCB) (2000). Management of municipal solid waste, *Delhi India.*

Chandrappa, R. & Brown, J. (2012). *Solid waste management: Principles and practice*. Springer Science & Business Media.-Verlag Berlin Heidelberg.

Chi Phuong Hoang. (2005). Audit of Solid Waste from Hotels and Composting Trial in Halong City Vietnam. Master's Thesis Department of Civil Engineering, University of Toronto, Canada*http//:electroniclibraryuniversityoftoranto.com*

Eriksen, G. N., Coale, F. J. & Bollero, G. A. (1999). Soil nitrogen dynamics and maize production in municipal solid waste amended soil. *Agronomy Journal*. 91(6) 1009-1016.

Evans, T.(2008). The Study of Environmental Awareness and Waste Minimization Approaches for Hotel Management in Belize. National Central University, Taiwan.

Festijo, B.T. & Yuzon, N. (2013). Waste management practices among counter service restaurants in Batangas city, Philippines. *International Journal of Academic Research in Business and Social Sciences,*3(8) 362-368.

Gidarakos, E., Havas, G. & Ntzamilis, P (2005). Municipal Solid Waste Composition Determination Supporting the Integrated Solid Waste Management System in the Island Of Crete. *Journal of Waste Management*. pp. 1-12, http/ww.elsevier.com/crete//waste/generation. Pdf.

Gondhalekar, D., Akhtar, A., Keilmann, P., Kebschull, J., Nussbaum, S., Dawa, S. & Mutup, T. (2013). Drops and hot stones: towards integrated urban planning in terms of water scarcity and health issues in Leh Town, Ladakh, India. *Ecological Health (Advances in Medical Sociology, 15*,173–193*.*

Gondhalekara, D., Nussbaumb, S., Akhtara, A., Kebschullb, J., Keilmannc, P., Dawad, S., Namgyald, P., Tsultimd, L., Phuntsogd, T., Dorjed, S., Namgaild, P. & Mutupe, T. (2013). Water-related health risks in rapidly developing towns: the potential of integrated GIS-based urban planning, *Water International, 38*(7): 902-920

Habitat (1994) "A Reference Handbook for Trainers on Promotion of Solid Waste Recycling and Reuse in the Developing Countries of Asia" Prepared by Environmental Systems Information Center, *Asian Institute of Technology (AIT)*

Hansen, J. E. & Sato, M. (2012). Paleoclimate implications for human-made climate change. In *Climate change* (pp. 21-47). Springer Vienna.

Hoornweg, D., Thomas, L. & Otten, L. (1999). "Composting and its applicability in developing countries" World Bank Working Paper Series No. 8 Washington, D.C. http://www.eawag.ch/organisation/abteilungen/sandec/schwerpunkte/swm/training/index

Hussian, M. (2000). Systematic geography of Jammu and Kashmir.*Rawat Publications,* Jaipure, India.

IEA (2005). CO2 Emissions from fuel combustion 1971. 2003. 2005. *Edition. Paris, France*

IHEI. (2002). Hotels care: Community action and responsibility for the environment. London, UK. *International Hotel Environmental Initiative*. http/www.cee.londonuk.edu.co.in.

IPCC. (2001). Climate change 2001: Impacts, adaptation and vulnerability.contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change James J McCarthy, Osvaldo F Canziani, Neil A Leary, David J Dokken, Kasey S White (eds.). United Kingdom: Cambridge University Press, 533-590.

Jain, A. P. & Kuniyal, J. C. (1994). Environmental Impact Assessment (EIA): A tool for effective management and decision making for tourism development in the Himalayan region of India. In: Himanchal- Indi a" Souvenir of 7th*Himalayan Tourism Advisory Board. Shimla,Department of Tourism,* 28-30.

Jain, P., Handa, K. & Paul, A. (2014). Studies on waste-to-energy technologies in India and a detailed study of waste-to-energy plants in Delhi. *International Journal of Advanced Research*. 2(1) 109-116.

Jakobsen, S. T. (1995). Aerobic decomposition of organic wastes 2. Value of compost as a fertilizer. *Resources, Conservation and Recycling*. 13(1): 57-71.

Jimenez, E. I., Garcia, V. P., Espino, M. & Moreno, J. H. (1993). City refuse compost as a phosphorus source to overcome the P-fixation capacity of sesquioxide-rich soils. *Plant and Soil*. 148(1):115-127.

Kessler Consulting. (2008). Public school waste composition study, innovative waste solutions 14620 N. Nebraska Ave., Bldg. E Tampa, FL 33613.

Kharbanda, O. P. & Stallworthy, E. A. (1990). *Waste Management towards A Sustainable Society*. Gower, England.

Kreutzmann, H. (2001). Development indicators for mountain regions. *Mountain Research and Development,* 21(2):132-139.

LEDe group. (2008). http/www.ladakh ecologicaldevelopmentgroup.co.in.

Medina, M. (2003). Globalization, Development, and Municipal Solid Waste Management in Third World Cities. *Available online at* http://www.gdnet.org/pdf/2002AwardsMedalsWinners/OutstandingResearch Dvelopment/martin_medina_martinez_paper.pdf.

Mensah, I. (2006). Environmental management practices among hotels in the greater Accra region. *Hospitality Management,* 25, 414-431.

Obirih, O. N. & Post, J. (2002). Quality assessment of public and private modes of solid waste collection in Accra, Ghana, *Habitat International*, 26,95-112.

Okazaki, W.K., Turn, S.Q. & Flachsbart, P.G. (2008). Characterization of food waste generators: a Hawaii case study. Waste Manag. 28, 2483e2494. http://dx.doi.org/10.1016/j.wasman.2008.01.016.

Otten, L. (2001). Wet–dry composting of organic municipal solid waste: *Canadian Journal of Civil Engineering.* 28 (1): 124–130.

Oyelola, O. T. & Babatunde, A. I. (2008). Characterization of domestic and market solid wastes at source in Lagos metropolis, Lagos, Nigeria. *African Journal of Environmental Science and Technology*, 2(12), 430-437.

Parandeh, M. & Khanjani, N. (2012). The Quantity and Quality of Hospital Waste in Kerman Province and an Overview of Hospital Waste Quantities in Iran. *World Applied Sciences Journal*, 17(4), 473-479.

Parfitt, J., Barthel, M. & Macnaughton, S. (2010). "Food waste within food supply chains: quantification and potential for change to 2050". *Philos. Trans. Roy. Soc. B* 365, 3065e3081. http://dx.doi.org/10.1098/rstb.2010.0126.

Parisakis, G., Skordilis, A., Andrianopoulos, A., Lolos, C., Andrianopoulos, J., Tsompanidis, X., Lolos, G. (1992). Physicochemical characterization of municipal solid waste of Kalamata Estimation in regard to compost production potential. *NTUA Laboratory of Analytic and Inorganic Chemistry,* Athens*.*

Parizeau, K. (2006). Waste characterization as an element of waste management planning: Lessons learned from a study in Siem Reap, Cambodia. *Elsevier doi: 10.1016/j.resconrec*. 2006.03.006

Peterson, C. (2013) Assessment of Solid Waste Management Practices and Its Vulnerability to Climate Risks in Maldives Tourism Sector, Submitted to: Ministry of Tourism, Arts and Culture Male', Republic of Maldives Submitted by: Solid Waste Management Consultant 119 West Pierce Street Easton, Pennsylvania 18042 USA

Pimenteira, C. A. P., Carpio, L. G. T., Rosa, L. P. & Tolmansquim, M. T. (2005). Solid wastes integrated management in Rio de Janeiro: input–output analysis. *Waste Management*. *25*(5):539-553.

Pirani, S. & Arafat, H. (2014). Solid waste management in the hospitality industry: A review. *Journal of Environmental Management*, 146, 320-336

Maclaven Yu, Chang Ching V Yu & Maclaven. V. (1995). A Comparison of Two Waste Streams Quantification and Characterization Methodologies, journal of waste management and research, 13, 343- 361

Pirani, S. & Arafat, H.A. (2014). Solid waste management in the hospitality industry: A review. Journal of Environmental Management. 146,320–336.

Powell, J. C. (1996). The evaluation of waste management options. *Waste management & research*. Vol. 14(6) pp. 515-526.

Quari, Naveed, Para, Altaf, Rangrez and Rihana. (2013). To Study the solid waste generated per bed per day at district Hospital Kargil a remote high altitude area. *Journal of Pharmacy*, 3(6):61-65

Rathi, S. & Kumar, P. (2014). Electrical energy recovery from municipal solid waste of Kanpur city. *International Journal of Scientific Research Engineering & Technology, 3,* (5) 923-929.

Rizvi, J. (1995). Trans-Himalayan Caravans, New Delhi. Oxford University Press.

Robinson, W. (1986). Solid waste management hand book a practical guide. *A Wiley Interscience Publisher*, Brisbane.

Saarinen, J. (2006). Traditions of sustainability in tourism studies. *Annals of Tourism Research*, 33(4): 1121-1140.

Sagwal, S.S. (1991). Ladakh, Ecology and Environment, publisher A.P.H. Delhi.

Selin, E. (2013). Solid waste management and health effects: A qualitative study on awareness of risks and environmentally significant behavior in Mutomo, Kenya.

Shah, S.A. (2013). Understanding of Tourists, Experiences and Perceptions in the Trans-Himalayan Cold Desert of Ladakh Region of India*. International Journal of Current Research*, 5(12):3773-3777.

Shanklin, C.W., Petrillose, M.J. & Pettay, A. (1991). Solid waste management practices in selected hotel chains and individual properties. J. Hosp. Tourism Res. 15, 59e74. http://dx.doi.org/10.1177/109634809101500106

Singh, S.K., Kaushik,V., Soni, S. & Lamba, N.. (2014). Waste management in restaurants: a review. *International Journal of Emerging Engineering Research and Technology*, 2 (2) 14-24.

Smith, Z. A. (2004). The Environmental Policy Paradox. 4thed. Pearson Education Inc. *Upper Saddle River, New Jersey.*

Staley, B. & Barlaz, M. (2009). Composition of Municipal solid waste in the united states and implications for carbon sequestration and methane yield. *Journal of Environmental engineering,* 135(10). 901-909.

Tacoli, C. (2012). *Urbanization, gender and urban poverty: paid work and unpaid carework in the city* (p. 48). Human Settlements Group, International Institute for Environment and Development.

Taiwo, A. M. (2011). Composting as a sustainable waste management technique in developing countries. *Journal of Environmental Science and Technology*. 4(2): 93-102.

Taylor, R., Allen, A., Schmoll, O., Howard, G., Chilton, J. & Chorus, I. (2006). Waste disposal and landfill: potential hazards and information needs.*Protecting groundwater for health: managing the quality of drinking-water sources*, 339-362.*http://www.bvsde.paho.org/bvsacd/cd59/protecting/sect2- 12.pdf.*

Tchobanoglous, G., Theisen, H. & Vigil, S.A. (1993). Integrated solid waste management: engineering principles and management issues. *McGraw-Hill, New York.*

Tchobanoglous, G., Theisen, H. & Vigil, S.A. (1994). Integrated Waste Management, McGraw-Hill, Singapore.

Thanh, N. P., Matsui, Y. & Fujiwara, T. (2011). Assessment of plastic waste generation and its potential recycling of household solid waste in Can Tho City, Vietnam. *Environmental Monitoring and Assessment*, 175(1-4), 23-35.

Turner, R.K. & Powell, J. (1991). Towards an integrated waste management strategy. *Environmental Management and Health*. 2 (1):6-12.

U.S. EPA. (2006). Solid waste management and greenhouse gases, *A Life-Cycle Assessment of Emissions and Sinks 3rd edition*

UN Food and Agriculture Organization (2013). Food wastage footprint: impacts on natural resources. http:www.fao. foodd waste.html.

UNEP. (1996). International source book on environmentally sound technologies for municipal solid waste management. International Environmental Technology Centre Technical Publication Series (6). *United Nations Environmental Programme.*

UNEP. (2002) Annual report. United Nations environmental programme division of technology, industry and economics: *International Environmental Technology Centre, Osaka, Japan.*

UNEP. (2009). Developing integrated solid waste management plan training manual, United Nations environmental programme division of technology industry and economics. *International Environmental Technology Centre, Osaka/Shiga, Japan.*

UNEPA (2007) Municipal Solid Waste Management, http//www.epa.gov/msw.html

United Nation. (2002). Report of the World Summit on Sustainable Development, Johannesburg. *South Africa.*

United Nations. (2000). State of the Environment in Asia and the Pacific 2000, *New York.*

United States Environmental Protection Agency. (1999). Organic materials management strategies. Solid Waste and Emergency Response (5306 W) EPA530-R-99-016.

UNPD. (2012). World urbanization prospects the 2011 revision. Department of economic and social affairs, population division, United Nations. *New York.* http://esa.un.org/unup/pdf.

USEPA. (2002). United States environment protection agency. Solid waste management: *A Local Challenge with Global Impacts http://epa.gov/climatechange/wycd/waste/downloads/overview.pdf*

Vallen, G. K. & Vallen, J. J. (2009). Check-in check-out: Managing hotel operations. Prentice Hal Professional Business USA.

VanWaning, A. (2010). Waste Characterization Study [WWW Document]. Chicago Department of Environment.http://www.cityofchicago.org/dam/city/depts/doe/general/RecyclingAndWasteMgmt

Wani, B.A. & Shah, W.A. (2013). Magnitude and seasonal variations of solid waste generation in tourist accommodation of Dal Lake, *International Journal of Environmental Sciences,* 2(1):57-62.

Wani, B.A., Shah, W.A. & Dar, M.Y. Dar, (2016). "Spatio temporal trends of solid waste generation in restaurants of Kargil Town of Ladakh, India", *International Journal of Current Research*, 8, (04), 30033-30038.

Winter, J.P. & Azimi, S.L. (1996). Less Garbage Overnight: A Waste Prevention Guide for the Lodging Industry [WWW Document]. http://infohouse.p2ric.org/ref/03/ 02129.pdf (accessed 10.07.15.).

Wolkowski, R. P. (2003). Nitrogen management considerations for landspreading municipal solid waste compost. *Journal of Environmental Quality*. *32*(5):1844-1850.

World Bank. (2012). What a waste: a global review of solid waste management. *Urban Development Series Knowledge Papers. http://documents.worldbank.org/curated/pdf .*

WTO. (2002). Tourist a catalyst for sustainable development in Africa. *Madrid, WTO.*

WWF-UK and IBLF. (2005)Why environmental benchmarking will help your hotel. A guide produced by the International Business Leaders Forum's travel and tourism program and WWF-UK .cited in www.*wgbis.ces.iisc.ernet.in/.../sustainable_waste_management system .*