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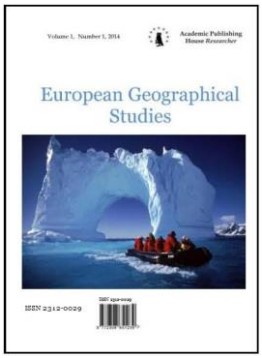

Problems of Sustainable Solid Waste Management in Urban Area: A Case Study of Varanasi City of India

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Abstract

This paper presents the current status of solid waste management, future estimation of waste generation and related problems in Varanasi city, India. The city is located on the proper ridge of kanker which forms the northern bank of the river Ganga for distance of little over 5 km. This part of the city is quite above the normal flood level. The city is 76.21m above the sea level. Varanasi (25° 13'N to 25° 24'N latitudes and from 82° 54'E to 83° 04'E longitude) is one of the most important and historic city located almost in the middle Ganga valley in the northern plain of India. For the convenience of civic administration, the city is presently divided into 90 Wards and 14 sanitary wards. Present work is based on the secondary data, in the first phase of the study, data pertaining to ward wise generation of solid Waste and distributions of waste storage depots for secondary storage is collected from MCV (Municipal Corporation Varanasi). The data regarding population is obtained from District Census Handbook, 2011. Data on generation of solid waste is calculated by multiplying the urban population by the amount of waste generated per capita per day. In the second phase of the study, ArcGIS.10.1 software was used to create maps for municipal solid waste management. Besides this preliminary field investigation was also conducted through GPS. The results shows that Like other cities in India, Varanasi is also facing the problems created by improper and unscientific disposal of solid waste. Due to increasing population, change in dietary habits, standard of living, consumption pattern of commodity and lack of awareness, the problem of collection, transportation and disposal of solid waste has become a herculean task for the local civic bodies or the municipal corporation of the city.

Keywords: solid waste management, MCV, population and problem of collection, transportation and disposal of solid waste.

1. Introduction

Solid waste management is an integral part of the urban environment and planning of the urban infrastructure to insure a safe and healthy environment while considering the promotion of sustainable economic growth. Rapid economic growth by industrialization of the developing countries in Asia has created serious problems of waste disposal due to uncontrolled and unmonitored urbanization (ISWA & UNEP, 2002). The country's municipal solid waste (MSW) generation showed an increasing trend parallel to the development of economic condition, urbanization, and rapid growth of population (Visvanathan et al., 2004). The problem is further aggravated by the lack of financial as well human resources trained in solid waste management

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practices in the sphere of collection, transportation, processing and final disposal. Whereas aspects like recycle, reuse and recovery of the solid waste is grossly demand and supply driven or disorganized in most cases. The waste quantity is increasing at an alarming rate in India due to rapid urbanization and a high population growth. The growth rate of population for India in the last decade was 17.6 % (Census of India, 2011). The issue is exacerbating in urban areas due to rapid population growth, coupled by an economic boom that encourages the consumption of goods and waste generation. The situation is becoming critical with the passage of time (Talyan et al., 2008). Domestic, commercial, biomedical and variety of toxic and domestic hazardous wastes are generally disposed of by the citizens on the streets, drains, open spaces, water bodies, etc., causing serious problems of health and environment (Abbasi et al., 2012). Several studies have been made to assess the problems caused by improper disposal of solid wastes in cities at national and international level. The WHO (1950) has studied about the environmental consequences and health problems taking into account such aspects as drinking water supply, waste water treatment, solid waste management, vector control, etc. (Rai, Nathawat, 2017). Stread (1960) has analysed the impact of technology and associated solid waste disposal problems. Bhide et al., (1992) in their study have critically analyzed the existing disposal sites and pointed out the deficiencies and have suggested the most economical solution for refuse disposal of Calcutta city. Olaniya and Saxena (1973) in their study have examined the relationship between sanitary landfill and river water quality. Flintoff (1976) in his study has suggested the most economical solution for waste disposal in developing countries. Park and Park (1979) also studied about effects of different types of pollution such as water, air and solid waste on human health. Brown (1982) studied about effects of sanitary landfill on ground water and streams. Jhon (1983) discussed about problems of waste disposal in the Third World cities in relation to climatic conditions. Kayastha and Kumra (1986) have highlighted the generation, collection and disposal methods of solid waste in some Indian towns and cities. The probable reason for its higher accumulation might be its greater sequestration capacity in soluble forms in the vacuoles of the root (Adriano 1986). Taylor et al., (1990) in their study have analyzed the psycho-social impacts caused by solid waste disposal in Southern Ontario. Khan (1994) in his paper identifies the problems of municipal solid waste generation in India in the context of population growth in urban areas. Teotia et al., (1996) describe about the effects of improper disposal of refuse and its management. The difference in per capita waste generation between low and high income groups vary from 180 gms. to 800 gms. per day (Sekher, 2007). As per a 2008 joint paper by NEERI and CPCB on the assessment of the status of MSW management in metro cities, state capitals, Class I cities, and Class II towns in India, (examining over 59 cities across India), the per capita generation in India lies between 0.2–0.6 kg per capita per day. Cities with a population of less than 0.1 million have a per capita waste generation of about 0.17–0.5 kg; however, cities with over 2 million population, mainly the metros and Class I cities such as Delhi, have a per capita waste generation in the range of 0.22–0.62 kg. According to a latest CPCB report, in 2016, India produced some 52 million tons of waste each year, or roughly 0.144 million tons per day, of which roughly 23 per cent is processed—taken to landfills or disposed of using other technologies. Like other cities in India, Varanasi is also facing the problems created by improper and unscientific disposal of solid waste (Rai, Nathwat, 2017). Due to increasing population, change in dietary habits, standard of living, consumption pattern of commodity and lack of awareness, the problem of collection, transportation and disposal of solid waste has become a herculean task for the local civic bodies or the municipal corporation of the city.

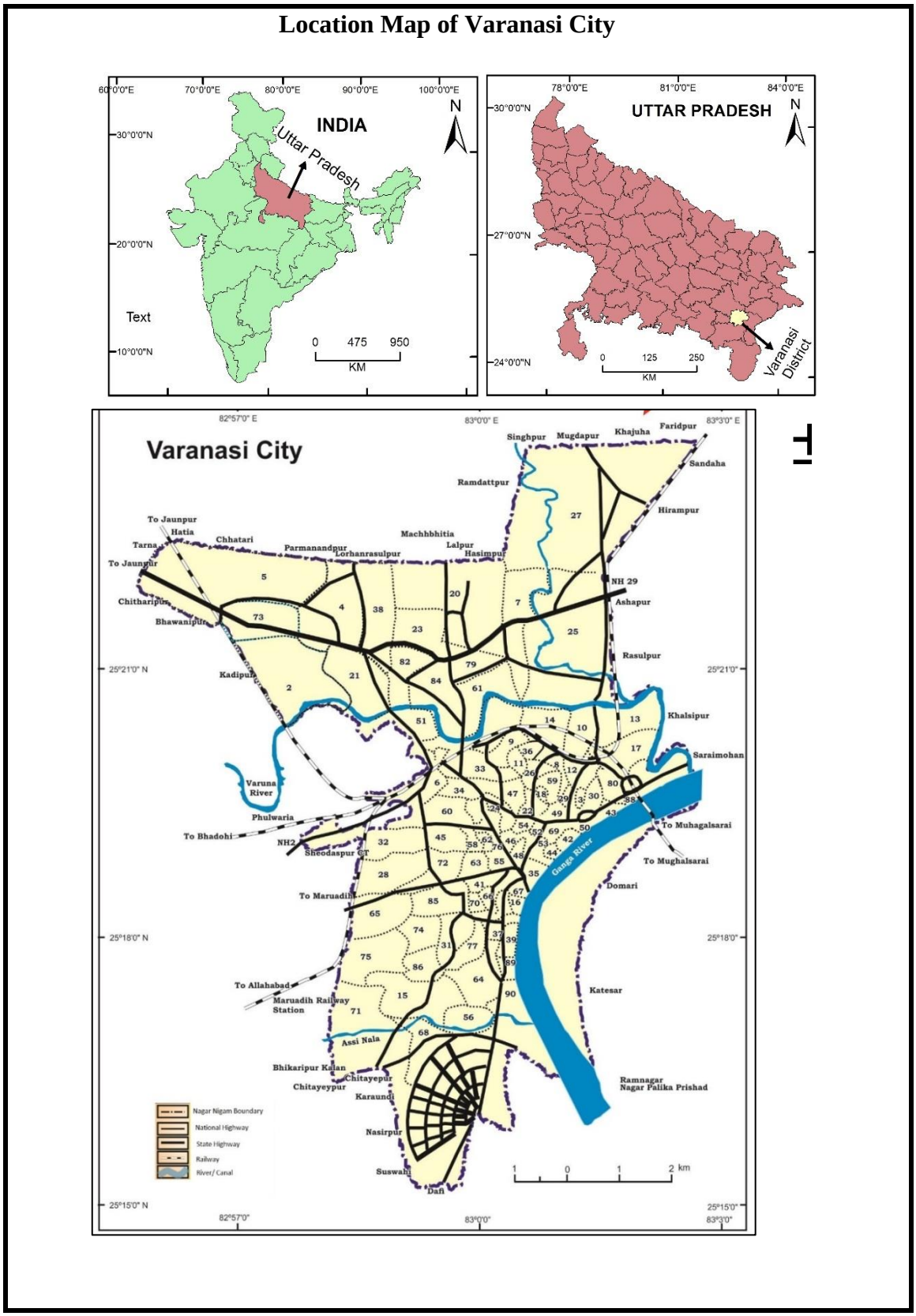

Fig. 1. Location map of Varanasi city

2. Study Area

Varanasi enjoys a commanding position on the crescent shaped left bank of the river Ganga (Fig. 1). The city is located on the proper ridge of kanker which forms the northern bank of the river

Ganga for distance of little over 5 km. This part of the city is quite above the normal flood level (Rai, Mohan, 2014). The city is 76.21m above the sea level. Varanasi (25° 13'N to 25° 24'N latitudes and from 82° 54'E to 83° 04'E longitude) is one of the most important and historic city located almost in the middle Ganga valley in the northern plain of India. It lies by rail at a distance of 696 km from Kolkata, 1505 km from Mumbai, 797 km from Delhi, 143 km from Allahabad, 230 km from Gorakhpur and 301 km from Lucknow- the capital of Uttar Pradesh. The city is also situated at one of the most important road systems of India since long back. The Grant Trunk road (G.T. road) passes through the city proper. From the very beginning, the river Ganga is serving as an important route of movement to facilitate the transportation of goods and traffic in addition to water supply to the city and as a natural defense barrier. For the convenience of civic administration, the city is presently divided into 90 Wards and 14 sanitary wards. For efficient and effective water supply, the city is divided into 16 water supply zones. As per 2011 Census, Varanasi city has a total population 11,98,491 (municipal corporation) of which 6,35,140 are males and 5,63, 351are females. In city total number of households were 1,90,835 and household density was recorded as 24 household/ha. Population density of the city is 150 persons/ha. About 70.30 percent of the population of city is literate. The sex ratio of the city is found to 887 females/1000 males (Mishra, Rai 2014).

Objectives of Study

i. To assess existing status of generation, collection, storage, transportation, treatments and disposal methods practiced in the study area.

ii. To assess how improved waste management practices can contribute to sustainable development processes in Varanasi city.

iii. To provide effective measures for future management and planning.

3. Material and Methods

The present work is based on the secondary data which is obtained from Municipal Corporation of Varanasi city, India. In the first phase of the study, data pertaining to ward wise generation of solid waste and distributions of waste storage depots for secondary storage is collected from Varanasi Municipal Corporation. The data regarding population is obtained from District Census Handbook, 2011. Data on generation of solid waste is calculated by multiplying the urban population by the amount of waste generated per capita per day. In the second phase of the study, Arc GIS 10.1 Software was used to create maps for municipal solid waste management. Besides this preliminary field investigation was also conducted through Global Positioning System.

Table 1. Status of Solid Waste Management in Varanasi

S. No.	Parameter	Present Status
1	Total household served with D2D collection	0 %
2	Total waste generation	600 TPD
3	Total waste collected	480 TPD
4	Total number of dustbins	373
5	Total number of vehicles	1000
6	Frequency of collection (trips/day)	2-3
7	No. of sweepers	2800

Source: Varanasi Municipal Corporation, 2013

Table 2. Availability of Equipment's for Solid Waste Management

S. No.	Particulars	Existing Number
1	Truck tippers	12
2	Compactor	35
3	Tricycles	800
4	JCB	3

5	Tata ace	150
	Total number of equipment	1000

Source: Varanasi Municipal Corporation, 2013

Table 3. Overall Composition of Waste Generation in the City

Biodegradable	**Recyclable**	**Other Waste**
51.25 %	15.30 %	33.45 %

Composition of Recyclable Waste					
Paper	**Polythene**	**Plastics**	**Glass**	**Metals**	**Miscellaneous**
32.8	25.6	7.3	5.7	5.8	22.8

Source: Municipal Corporation Varanasi

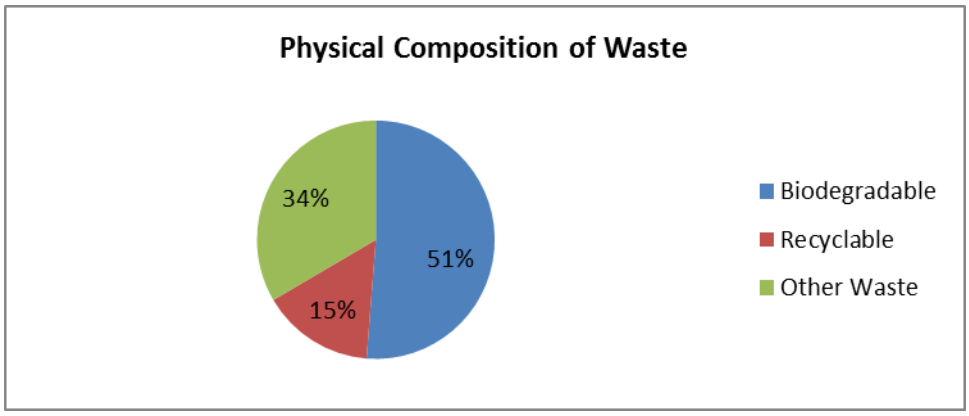

Fig. 2. Physical Composition of Waste

4. Result & Discussion

Solid Waste Management and Existing Systems

The solid waste management system in Varanasi is managed by Varanasi Municipal Corporation. Till recently, the waste management was being managed by A2Z Infrastructure Private Limited Company Kanpur Uttar Pradesh India. The concessionaire was responsible for door to door collection, transportation, treatment and disposal of solid waste from all wards. However, due to non-payment of past dues by Varanasi Municipal Corporation, the concessionaire has abandoned the project and now the contract has been terminated. Now Varanasi Municipal Corporation is making use of its own resources to collect and transport the solid waste from other parts of the city to the dumping site in addition to street sweeping. Door to door (D2D) collection facility has been withdrawn, due to termination of contract. Waste is collected from secondary collection points by Varanasi Municipal Corporation and transported directly to dumping grounds. It has also been found that generation of solid waste was 600 Tons per day (TPD) in 2013. While total waste collected is 480 Tons per day. Waste collected is disposed of in a landfill site at 'Padav' along Ramnagar road. There are 1000 equipment's including 12 Truck tippers, 35 Compactor, 800 Tricycle, 3 JCB and 150 Tata ace for the transportation and disposal of solid waste. Vehicles are operated by the concessionaire and make 2-3 trips a day. Currently, most of the vehicles are not being operated as Varanasi Municipal Corporation employees do not have the skill to operate these vehicles. All these vehicles were procured under JNNURM in 2011. There are 2,800 permanent and contractual sanitary workers for street sweeping. In the absence of door to door collection facility in all the wards and lack of practice of waste storage at source, majority of the waste is collected by street sweepers. Total manpower available with Municipal Corporation could not manage 600 Tons every day. Most of the waste generated comprises biodegradable, compostable, and recyclable materials. This is due to the high quantum of religious and vegetable waste the city generates along with a high amount of plastic waste. Recyclable items include paper, plastics, polythene, glass, metal and other miscellaneous items. The disposal site is located 20 km. away from the city in

Karsada on a 40 acre site. Currently, the site is not operational as it is still being developed and it is expected. Population growth and solid waste generation in the city has varying trend and correlation between population and solid waste generation of city is not cop with suitable manner. The solid waste generation in 2041 is expected to be 1206 Tons per day. This has been calculated for the projected population, with waste per capita increasing from 400 grams in 2013 to 420 grams in 2041. City has so far adopted only open dumping method for the disposal of waste. Currently, the wastes are not treated in a systematic and scientific manner. Status of solid waste management and availability of equipment's for solid waste management are given in the Table 1 & 2. Physical composite of waste is shown in the Fig. 2.

Table 4. Ward Wise Generation of Solid Waste

S. N.	Name of Wards	Solid Waste Generation/cap./day	S. N.	Name of Wards	Solid Waste Generation/cap./day
1	Indrapur	6.75	46	Kamalgarha	5.71
2	Vinayaka	6.16	47	Omkaleshwar	4.87
3	Tarna	8.12	48	Madhyamaheshwar	4.49
4	Rajghat	3.51	49	Jangamwari	2.74
5	Narayanpur	6.71	50	Saraiya	6.81
6	Sirsauli	5.00	51	Daraganj	4.75
7	Hukulganj	6.80	52	Piyarikala	5.31
8	Nagwa	8.41	53	Birdopur	3.81
9	Lahartara	6.50	54	Bhadaini	3.07
10	Sunderpur	6.40	55	Iswargangi	5.06
11	Chawkaghat	5.16	56	Jalalipura	6.60
12	Tulsipur	8.08	57	Didhori Mahal	6.05
13	Sarai Surjan	9.83	58	Nawapura	5.86
14	Nawabganj	3.22	59	Lahangpura	4.18
15	Nadesar	4.01	60	Luxbagha	4.08
16	Dindayalpur	5.15	61	Pandariba	5.11
17	Shivpurwa	10.34	62	Raj Mandir	3.46
18	Khajuri	5.40	63	Garhwasi Tola	3.75
19	Shivpur	7.86	64	Ramapura	4.02
20	Sikraul	5.53	65	Baghara	4.66
21	Habibpura	3.90	66	Prahlad Ghat	5.30
22	Rajabazar	6.50	67	Gola Dinanath	3.84
23	Aliapur	7.54	68	Benia	4.01
24	Jagatganj	3.41	69	Sarai Gowardhan	4.46
25	Jolha	11.59	70	Pandey Haweli	3.05
26	Ramrepur	6.01	71	Pathani Tola	6.14
27	Mawaiya	6.58	72	Rewari Talab	4.38
28	Newada	7.98	73	Lallapura Kala	4.00
29	Nai basti	6.32	74	Dashashwamegh	3.95
30	Sarnath	5.42	75	Dhupchandi	5.58
31	Loko-chhittupur	7.00	76	Baluabir	4.86
32	Naria	9.36	77	Ranipura	5.80
33	Pandeypur	7.57	78	Bangali Tola	3.61
34	Konia Gao	7.19	79	Harha Sarai	3.07
35	Kajipura	4.74	80	Katehar	4.06
36	Paharia	7.39	81	Jamaludinpura	3.76
37	Lalpur Khurd	6.95	82	Bandhukachchibagh	3.95
38	Bajardiha	6.13	83	Kal Bhairav	4.30

39	Shivala	3.87	84	Kamalpura	3.11
40	Sigra	3.87	85	Basnia	4.93
41	Kameshwar Mahadev	3.79	86	Kajisadullapura	4.68
42	Katuapura	4.67	87	Aagaganj	3.23
43	Khojwa	4.68	88	Rasulpura	3.13
44	Bhelupura	4.42	89	Chhittanpura	4.09
45	Chetganj	4.18	90	Madanpura	3.44

Source: Based on calculation on the basis of per capita per day generation of solid waste

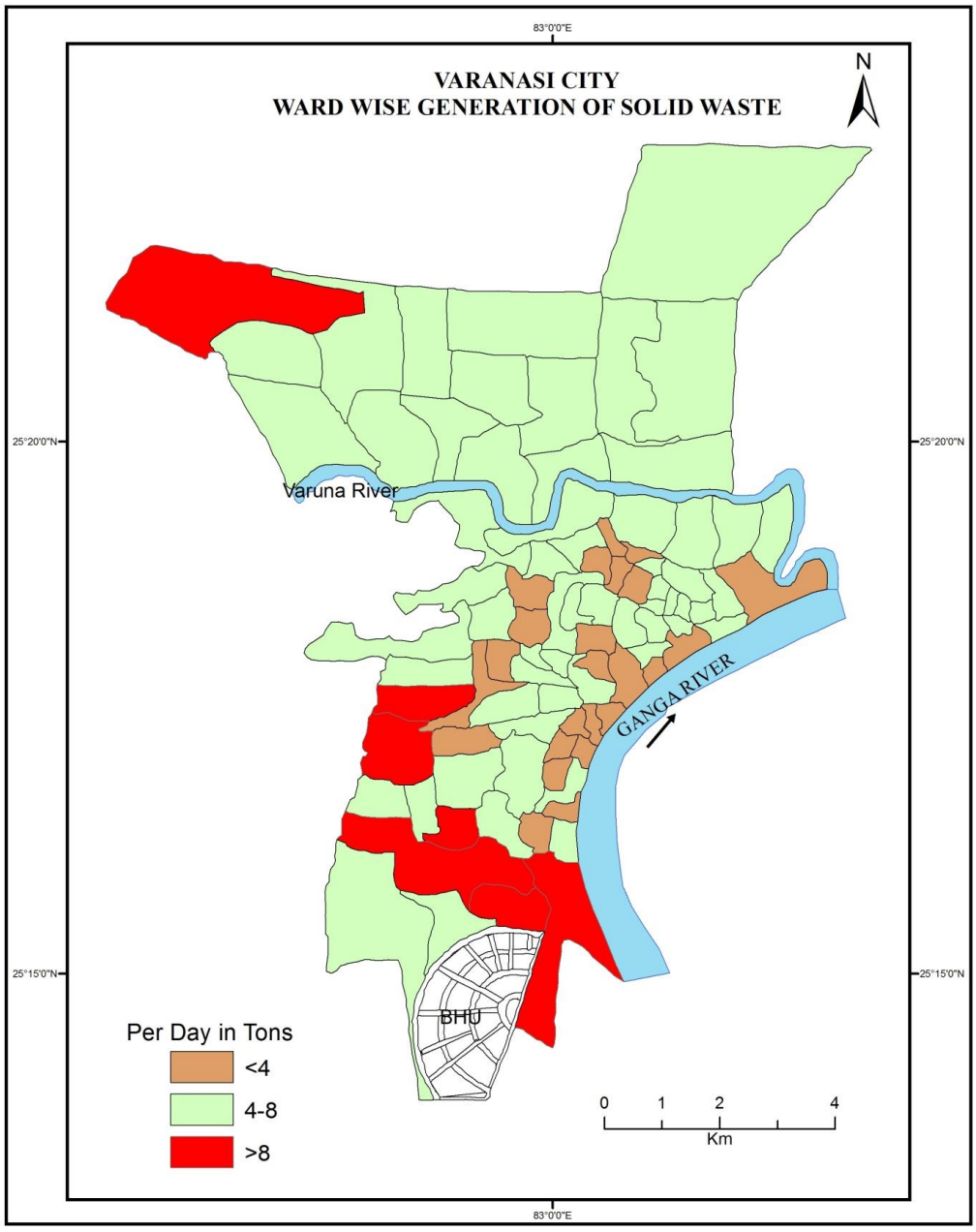

Fig. 3. Ward Wise Generation of Solid Waste

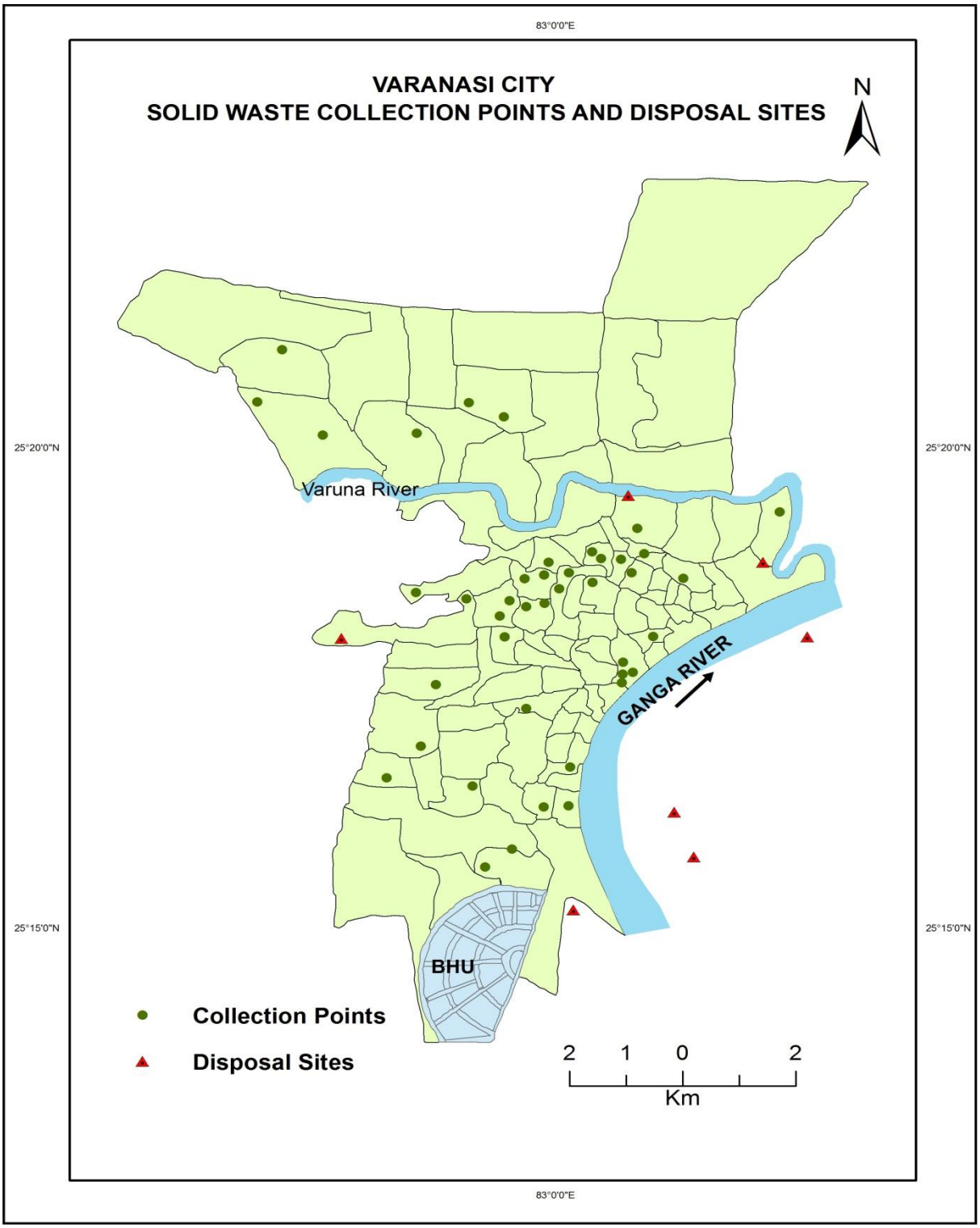

Fig. 4. Solid Waste Collection Points and Disposal Sites Identified through GPS Survey

Per Capita Waste Generation Parameters

Urbanization is now becoming a global phenomenon. Rapid urbanization and uncontrolled growth rate of population accelerate the generation of municipal solid waste. The increasing population directly influences the municipal solid waste generated around the surrounding areas. The socio-economic profile of the population, the consumption patterns govern the characteristics

of the waste generated. The industrialization not only influences the quantity of waste but also affects level of urbanization & increases population levels which results in increase in the overall waste generated. In Varanasi, approximately 2.6 lack metric tons of waste is generated per year, with per capita values ranging. From 0.40 to 0.42 kg per person per day and an average of 0.41 kg/capita/day. From the above scenario we can analyze that per capita waste generation is gradually increasing decades to decades and the figure also indicating that average kg per capita per day of waste generated within this region up to projected year.

Estimation the Quantity of Waste Generation in Each Year up to projected Year

Storage of waste at source is the first essential step of Solid Waste Management. Every household, shop and establishment generates solid waste on day to day basis. The waste should normally be stored at the source of waste generation till collected for its disposal. In Varanasi, such a habit has not been formed and in the absence of system of storage of waste at source, the waste is thrown on the streets, treating streets as receptacle of waste. Generally no bins for storage of domestic, trade or institutional waste are kept at source.

The future amounts of waste are closely coupled to economic growth given un-changed waste intensities in economic and human activities. Again the waste generation is directly proportional to the rate of change of population. A mathematical calculation is ultra-process beginnings with the estimation of future population based on the average increase in population of last two decades and then calculate the future amount of municipal solid waste generation as below:

$$\text{Future population } (Pf) = Po\,(1+R/100)^{y}$$

Here, Po= Initial Population, R= Percentage of growth rate = {(x1+x2)/2}/10, x1&x2 is the population increasing percentage of last two decades and y = years.

The rate of increasing population is very decades to decades. Here average increasing rate i.e. 2011-2021 is 29 %, 2021-2031 is 22 % and 2031-2041 is 23 % are chosen for the study.

Future amount of municipal solid waste generation per day

$$\text{Quantity } (Wq) = (Pf) \times (wr) / 1000$$

Here, Pf = Predicted population, and wr = Waste generation rate (kg/capita/day)

Table 5. Population and Waste Generation Projection of Varanasi up to Projected Year

S. No.	Year	Population	Quantity (MT/Day)
1	2011	1198492	479
2	2021	1457579	591
3	2031	1874945	776
4	2041	2376749	998

Source: Calculated from the Data of Municipal Corporation of Varanasi

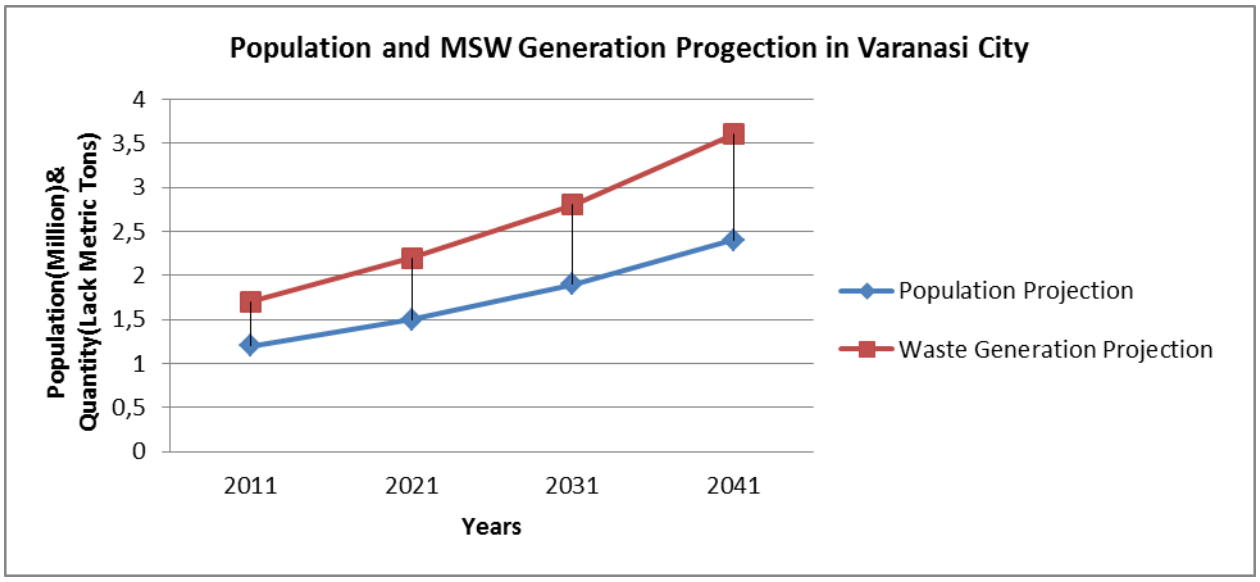

Fig. 5. Population and MSW Generation Projection in Varanasi City

Projections for urban municipal solid waste generation in 2041 were made by factoring expected growth in population and estimated per capita waste generation. The population data collected from census of India as per the report of technical group on population projections constituted by the national commission on population to the office of the Registrar general & Census commissioner of India. The population projection is calculated by forecasting method. The population growth in Varanasi from 2011 to 2041 shall have a growth of 21 % in 30 years at a rate of 2.25 % of annum. This growth rate is considered in the model from 2011 to 2041 to predict the MSW generation. The MSW data collected from various municipalities as per the office records and survey work. It is estimated that the amount of waste generated in Varanasi will increase at a per capita rate of approximately 0.41 % annually is considered for estimate of MSW from the year 2011 to 2041. The population versus increase of municipal solid waste generation of year wise from 2011 to 2041 is obtained from forecasting method shown in fig. 5.

Ward Wise Generation and Collection of Solid Waste

The per capita per day contribution of garbage is calculated as 400 gms. The generation of solid waste also varies from one ward to the other, depending upon size of population, dietary habits of the residents, type of the residential area and functional characteristics of the ward. (Fig. 3) shows the spatial variation of solid waste generation in Varanasi. The quantum of solid waste generation of wards have been calculated on the basis of 2011 District Census Handbook data and present generation of solid waste per capita per day (400 gms), (Fig. 3 & Table 3). Further, it is observed that generation of solid waste also varies from one season to another. Some sizeable portion of the city remains water logged during rainy season, causing interruption in the regular collection of garbage. Consequently, less amount of garbage is collected during these months. For smooth collection of garbage, the corporation area (79.79 km^2) has been divided into 90 wards with 42 collection sites (Fig. 4) these collection sites have a specific open enclosure locally called 'taka', characterized by walls on three sides. These open refuse depots on the one hand provide access to cows, pigs, birds and rodents and on the other the decomposed filth transmits diseases through viruses and bacteria. In many parts of the city, particularly along the river front, the lanes are so narrow that it becomes difficult to transport garbage up to the specified disposal sites. As a result, garbage finds its way into the river Ganga, increasing organic pollution load of the river. in addition, a number of private nursing homes, hospitals, diagnostic centers and pathological labs are frequently involved in dumping the waste on the roads and these have mushroomed in recent times, seems to the worst affected on account of improper disposal of bio-medical wastes. In the city primary collection of wastes from the door steps has not been introduced in any part of the city. The entire city population continues to through the waste on the street, open space, drains,

water bodies etc. during the course of field investigation, it has been observed that only some people dispose of waste at the waste storage depots. The primary collection of MSW is done manually by conventional wheel barrows and hand carts. The waste from households is taken out for collection in garbage bins, located in different parts of the city. At the primary stage the sweepers collect waste and put into dust bins on street corners from where it is transported to secondary collection depots. Solid waste generated in the city is not given any treatment before disposal. There is no specific site for waste disposal and it is dumped in and around city in the nearest available low lying areas. Population and waste generation projection of Varanasi up to Projected Year (2041) is given in the Table 4. Population and MSW generation projection in Varanasi City is shown in the Fig. 5.

Review of Existing Problem

Some of the problems faced by the Municipal Corporation of Varanasi in the solid waste management. Currently, there is no proper system of collection and transportation of the waste. Loading and unloading is fully manual causing health hazard to the workers. Varanasi has not provided adequate number of dustbins for storage of wet and dry wastes for the clearance through their regular primary collection process. As per the norms/standards Municipal Corporation of Varanasi has to provide containers, for proper collection of waste wherever possible throughout the city for better management of the waste. The vehicles are not covered resulting in spread of foul smell as the vehicle moves around the town for collection and disposal of the waste also the lighter waste materials fly and fall down the way. There is not enough staff for sweeping the roads of Varanasi, making it difficult to clean the city. Condition of the vehicles carrying waste is very poor and needs proper maintenance/replacement. An important issue here is that, the bio-medical waste is also disposed of along with the municipal solid waste at this site. Monitoring process is also non-existent at the dumping site. Lack of formal sanitary landfill site, lack of segregation of waste and need to introduce composting to minimize the quantum of waste going to landfill. Waste dumps in nallahs and rivers lead to water logging and unsanitary conditions.

5. Conclusion and Suggestions

On the basis of this study, it may concluded that solid waste management in Varanasi city is in very bad shape. The present work reveals that municipal corporation is unable to meet the requirement of increasing population due to inadequate manpower and modern equipments. Proper disposal of bio-medical wastes from hospitals, diagnostic centers and pathological labs could not be takes place in the city. Such wastes not only cause threat to environment by contaminating the land, air, and water resources but also believed to cause intestinal, parasitic and skin diseases among sanitary workers engaged in collecting refuse .In the city Due to lack of adequate capacity to transport wastes and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped nor well managed. Also, they are failed to protect against contamination of soil and groundwater. At present most of the Municipal solid waste in the city is disposed of unscientifically. Waste treatment and disposal sites can create health hazards for the neighborhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills attract all types of vectors, insects and rodents that spread diseases such as dysentery, diarrhea etc. which affects the health of human beings. To minimize the solid waste generation adopt the policy of 4R's. That is Refuse, Reuse, Recycle and Reduce. The current regulations (MSWM Rules, 2000) are very stringent. Norms are to be developed for ensuring a proper MSWM system. But unfortunately, there is a large gap between policy and implementation. Therefore, there is urgent need to bridge up these gaps. Besides these, the involvement of people and private sector through NGOs should be sought to improve the efficiency of MSWM. Public awareness should be created at large scale for awaking people from hazards caused from improper disposal of garbage. Littering of MSW should be prohibited and house-to- house collection of MSW should be organized through methods like collection on regular, pre-informed timing and scheduling. Furthermore, municipal authority should maintain storage facilities in such a manner that these do not create unhygienic and insanitary conditions. Proper maintenance of MSW transportation vehicle should be done. Municipal Corporation of Varanasi should involve proper monitoring for safe disposal of daily solid waste. Solid waste management is definitely not only a technical challenge. Understanding and taking into account the environmental impact, financial and economic

calculations, social and cultural issues, and the institutional, political and legal framework, is most crucial for planning and operation of a sustainable solid waste management in the city.

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