International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor 5.46 Volume 6, Issue 4, April 2019
Website- www.aarf.asia, **Email** : editor@aarf.asia , editoraarf@gmail.com

Municipal Solid Waste Management in Haridwar, India- A Public Private Partnership

Seema Singh and Ruchi Saxena
Associate Professor,Department of Zoology and Associate Professor, Department of Chemistry, Nari Shiksha Niketan (PG) College, Kaiser Bagh, Lucknow-226001

Abbreviated Short Title: Public Private Partnership in Solid Waste Management

Abstract
Rapid urbanisation, industrialization and infrastructure development along with changes in lifestyle has resulted in the accumulation of waste in cities and towns, causing a threat to the health and well-being of citizens and endangering the environment. Thus the municipal solid waste management has become a major problem in cities and towns of India. The waste has to be collected, transported and disposed of sustainably by an eco-friendly method. With the initiative of the Government of Uttarakhand after the Swachh Bharat call from the Central Government, a Public-Private Partnership (PPP) was done with KRL Waste Management Haridwar Pvt Ltd. to tackle the menace of MSW in Haridwar city. The present study has been conducted for nine months (August 2018-April 2019) to assess the latest scenario of the municipal solid waste management process. KRL Waste Management Haridwar Pvt Ltd has been able to motivate the citizens for segregation of waste at homes and has been able to process 46774 tons of waste, producing 8460 tons of compost from the bio-degradable waste and sent the refuse for the Sanitary landfill at the Sarai village, Haridwar. This PPP has been very successful and has moved up Haridwar to 244th rank from an earlier rank of 376 in Swachh Survekshan 2020 of India.

Keywords: MSW, Haridwar, Public Private Partnership (PPP), compost, landfill.

Introduction

Waste Management in Ancient India

The drainage system of the Harappan cities in India was the best known to the world in ancient times. Excavations in Mohenjo-Daro and Harappa revealed toilets and baths in houses linked to the city's central drainage network and the solid waste was discharged into a rectangular jar soak-pit for collection (Figure-1). The bricks prevented the dirty water and the solid waste from leaking. The drains were built on either side of the roads and covered with stones which could be removed for cleaning them(Kumari, 2012, Kenoyer, 2001).

Figure1: Drainage system in Indus valley civilization.
Source: Courtesy of Professor Jonathan Mark Kenoyer

But in the Vedic period, India was rural and pastoral and there is no mention of urban life. People in the Indian villages till date follow easy techniques and dig small holes in their backyard to collect daily household waste and cover it with mud/sand till the pits get levelled. Slowly India moved from villages to cities with an urban lifestyle and the cities and towns got littered with garbage presenting an ugly look, endangering the environment and posing a health risk for the people. The citizens are not aware of the detrimental effects of the waste created by their careless attitude which poses a challenge for the urban local bodies (ULBs). The meteoric rise in urbanization, industrialization and economic development has resulted in increased municipal solid waste(MSW) generation per person. India generates approximately 1,41,064tons of MSW per day, of which approximately 1,27,531tons(90%) is collected and approximately 34,752tons(27%) is treated (CPCB, 2000). MSW generation per capita in India ranges from approximately 0.17kg per person per day in small towns to approximately 0.62 kg per person per day in metro-cities(Kumar *et.al*. 2009). The World Bank study of 2016 also states that India will generate an annual waste of approximately 387.8 million tonnes by 2030 and 543.3 million tonnes by 2050.(Deol, 2020).

Achieving sustainable SWM within India is very difficult with its diversity, with many different religious groups, cultures and traditions. Current SWM systems are inefficient, resulting in the waste having a negative impact on public health, environment and economy. Thus there is an urgent need to move towards sustainable SWM, with ingenious and mechanised waste management systems. As per the international standards, Municipal Solid Waste Management involves six basic principles which are (1) waste generation, (2) storage, (3) collection, (4) transfer or transport, (5) processing and (6) disposal respectively (Memon, 2020). It is alarming that about 12 million tons of inert waste is generated in India yearly, from street sweeping alone (Joshi and Ahmad, 2016). Solid Waste Management (SWM) is an essential service provided by urban or Municipal local bodies (ULBs) across the country, governed by Municipal Solid Waste Management and Handling Rules, 2016 (Waste Management Rules 2016). For easy and sustainable disposal the waste has been categorized as follows:(Table 1)

Table1: Waste Composition and Characteristics

Source	Typical waste generators	Types of solid wastes
Residential	Houses, multi storey buildings (Apartments)	Food waste (Garbage), Rubbish, Ashes and residues, Bulky waste , Street waste, Dead animals, Household, Spoiled food wastes paper, wood, Construction and demolition waste , plastics, textiles, leather, yard wastes, glass, metals.
Industrial	Light and heavy manufacturing, fabrication, construction sites, Factories, treatment plants, power and chemical plants.	Industrial waste and sludge, Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes. Card boardashes, special wastes (bulky items, consumer electronics, white goods, batteries, oil, tires).
Commercial	Hospitals, shops, stores, hotels, markets, street food corners, restaurants, office buildings.	Market refuse, handling waste, Paper, cardboard, plastics, wood, food wastes, glass, metals, hazardous wastes paper, cardboard, cartons, boxes, clothes, leather, bedding, plastic.
Institutional	Schools, hospitals, institutions, prisons, government centres.	Laboratory waste. Paper waste.
Municipal services	Street cleaning, landscaping, parks, riverfronts, other recreational areas, water and wastewater treatment plants. parks, gardens	Street sweepings (dirt, leaves and animal droppings, landscape and tree trimmings), general wastes from parks, beaches, sludge. metals, stones, bricks, glass, heating of buildings, cinders, clinkers, etc. Auto parts, other large appliances, tires, stoves furniture, carcasses, rubble wires.
Process (manufacturing , etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings. manufacturing operations Hazardous waste (pathological waste explosives, radioactive materials).
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Agricultural wastes, hazardous wastes (e.g., pesticides). Horticulture waste, tree trimmings, leaves, waste from gardens and orchards.

Uttarakhand a state in the North of India, envisioned the Swachh Uttarakhand in line with the Swachh Bharat Mission to ensure hygienic, clean and litter free environment across the state. The waste is to be treated as a resource, managed scientifically in a sustainable manner for achieving zero waste for landfills by 2040. The challenge is to improve the solid waste management service, which is fraught with lack of financial resources, appropriate skills and

technological incompetence in the public sector. Opting for PPP mode (MoF, 2009)would give greater benefit to the public sector by reducing the financial stress and also give value for the money invested. Therefore for a sustainable MSW management Public-Private-Partnerships (PPP) has been promoted by the Government of India. (Joshi and Ahmad, 2016). There are numerous facets that are yet to be understood while using PPP in the waste management sector. The present study of Haridwar city was undertaken during August 2018 to April 2019 to assess the latest scenario of Municipal solid waste management process as a Public-Private Partnership(PPP) with KRL Solid Waste Management (H) Pvt. Ltd.

Material and Methods

The present study was carried out with a primary data collection which comprised of a quantitative estimation of waste and qualitative analysis of the compost generated. The field study was conducted in the city and at the disposal site. Direct communication was established with the Haridwar Nagar Nigam(HNN), KRL and the local residents to assess the outcome. SWM operation in Haridwar is as follows: 1) Waste collection 2) Record keeping 3) Transportation 4) Monitoring 5) Staff involvement in the collection and disposal process 6) Technical equipment and management process observation.

Site description

Geographically, the city of Haridwar lies between Shivalik Hills in the North and the Ganges River in the South (Figure 2). It is located on the latitude 29.96^0 north and longitude 78.16^0 east in the Southwestern plains of Uttarakhand at a height of 314m from the sea level, (Geography of Haridwar covering an area of 19.17Sqkm with a population of 1,890,422estimated to rise to 2,192,890 by 2021 (Census of India, 2011).The city bears unique history of a religious character with a rich cultural heritage and attracts millions of pilgrims and tourists with spiritual pursuits. The Hindu religious congregation, the Kumbh and the Ardh Kumbh melas are held every12 and 6 years respectively. Haridwar with a current population of 0.2 million and mean floating population of 0.16 million attracts an annual average of 8 million tourists annually (The growth rate of the floating population was estimated to be 2.5% per annum. According to a broad estimate, the city has 2.6 lakh/day of floating population Kashthala *et al*, 2019),presently which is expected to rise to 6,29,492 by 2025. Haridwar is also an emerging centre for ayurvedic treatments and yoga (Patanjali).

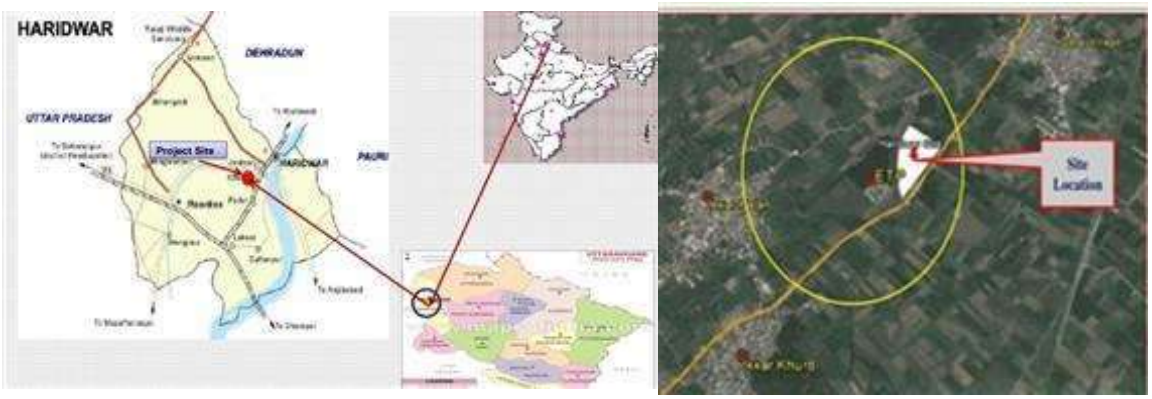

Figure 2: Location of Haridwar City

Therefore the Government of Uttarakhand under the Swachh Uttarakhand programme undertook various measures by guiding ULBs towards sustainable solid waste management as per SWM rules by adopting suitable measures for waste minimization at source with an emphasis on the principles of five-Rs comprising of reduce, reuse, recycle recover and rethink. To develop hygienic and disease-free cities Public-Private-Partnership were made with proper systems of segregation, collection, transportation, processing, treatment and

disposal. In the city of Haridwar the PPP was established between the Haridwar Nagar Nigam (HNN) and KRL Waste Management (H) Pvt. Ltd. in August 2012 as a project under JnNURM but became operational only in 2017.The major sources of MSW generation of the city are domestic, shops and commercial establishments: hotels(270), restaurants(250), dharmshalas(280), fruit and vegetable markets(3). Haridwar city alone generates approximately 270 Metric Tons(MT) of waste daily, 350 MT/day waste in the peak pilgrimage months. The average per capita generation of waste is about 0.5kg per day(SWMPShivalikNagar, 2018)Thus the MSW of the city comprises of following physical components(Figure 3)

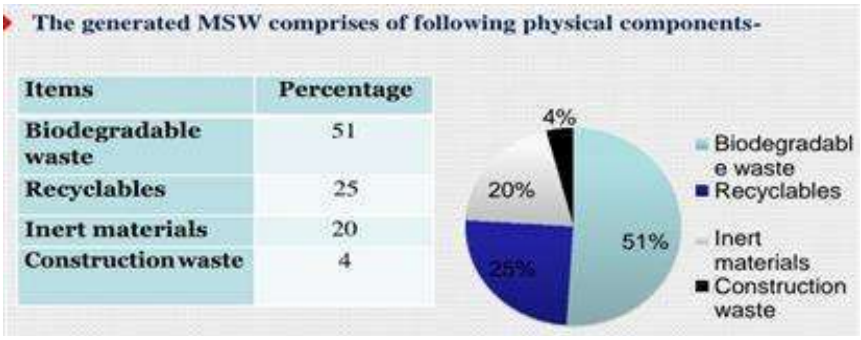

Figure-3: Components of the MSW

The MSWM of Haridwar city is carried out by the following steps:

01. Collection of waste

i) Primary Collection

The primary collection is the first stage of urban solid waste management process and is a local public good. The public is more concerned about the efficiency in the removal of garbage from the streets as it is unsightly as well as a health hazard. Prior to the partnership of the Municipal Corporation and the KRL there was no uniform primary collection system in the city baring a few localities. Haridwar Nagar Nigam sweepers and sanitary workers would sweep the streets and accumulate the waste in small heaps which were subsequently loaded manually or mechanically in community containers/bins or directly in vehicles for transportation to the disposal site. It was observed that the community waste bins were also used by hotels, industries and other commercial enterprises along with household waste for the transfer of their waste to the disposal site. (Kumar et al., 2009). To ensure the removal of all SW from all the 60 wards(1200 houses/ward) (Figure 4).

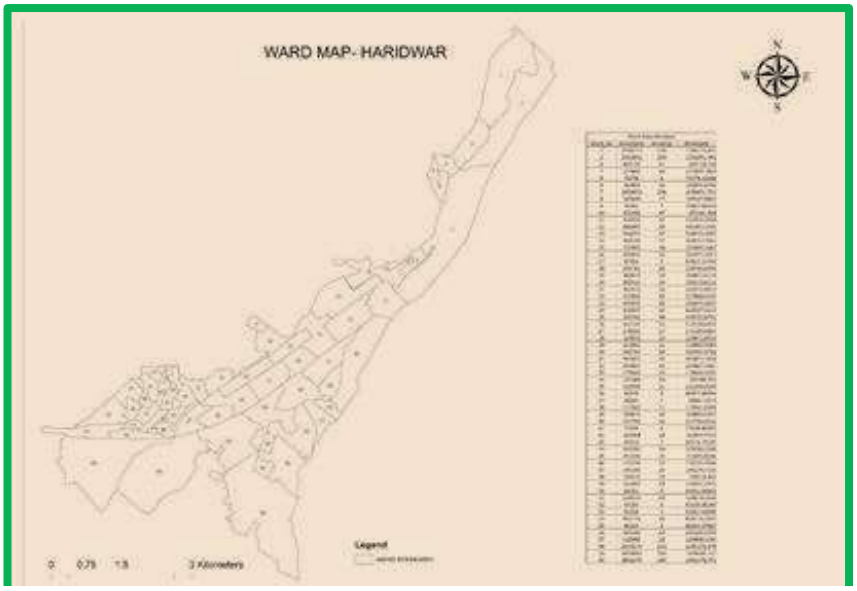

Fig -4 : Ward map of Haridwar

KRL ensures segregation of waste before door to door collection by deploying 154 cycle-rickshaws(Rede Wale)and 10 mini trucks (Chote Hathi) (Figure 5 with twin colour-coded(blue-green) dustbins.

Figure 5: Rede wale (Collection of Waste)

ii) Secondary Collection

The secondary collection involves the collection of waste from 220 community containers and bins with capacities of 0.5m^3, 1m^3 and 4.5m^3 placed at different locations (also called collection points) of the city, for secondary storage of solid waste. In addition to the above-mentioned containers and bins, there are about 15 open collection points and 2 Dallas (Constructed enclosures) located in different sites of the city (Figure 6)

Metal containers (175) Dalla(2)

Figure-6: collection site

02. Transportation

Transportation is largely a mechanical function and can be done either by the municipal authority HNN or by a private operator KRL efficiently with vehicles like Tractor-trolley, Tipper-truck, Chhota-Hathi, mechanical loader, JCB loader cum excavator, dumper

placer,refuse compactor, mini refuse collector and tarpaulin-covered vehicles. KRL plans an optimal route daily and also provides the finance for the fuel for running of vehicles. On site observations revealed that the waste is transferred from stations to the Sanitary landfill site in covered vehicles. About 90% of the vehicles are operative whereas the remaining 10% are either defunct or under repair. There is a facility for weighing the loaded vehicles before disposal for assessment of the quantity of solid waste disposed every day. Presently in Haridwar the following vehicles and equipment are used for transportation of solid waste (Table 2):

Table 2: Types of vehicles used for transportation of MSW

S.N.	Vehicle	Capacity (ton)	Total quantity
1	Tractor Trolley (Nagar Nigam)	3-4	2
2	Tractor Trolley (KRL)	5-6	1
3	Tractor Trolley(KRL)	7	1
4	Tractor Trolley (KRL)	9	1
5	Tractor Trolley (KRL)	9-10	1
6	Tractor Trolley (KRL)	8.5	1
7	Tractor Trolley (KRL)	4	1
8	Tipper Truck (KRL)	7	5
9	Tipper (Nagar Nigam)	6	1
10	HYVA(KRL)	16	1
11	Chhota hathi (Nagar Nigam) Chhota hathi (KRL)	3	2 8
12	Dibba pressure	4 ton	3
13	Compactor (Nagar Nigam)	3-4 ton	7
14	Tractor loader (Nagar Nigam)		2
15	JCB machine(KRL)		1+2
16	Bobcat(KRL)		1

Figure 7: vehicles transporting MSW

03**. Segregation of waste**

There was no segregation of waste in the Indian household and it was both ill organized and unscientific at the community bins. The construction and demolition debris, broken plastic, commercial and industrial refuses and the electronic waste of various types too were not segregated. E-waste components are nonbiodegradable, they contain toxic materials which when recycled produce toxic smoke and also leach in local water tables from the landfills. Thus there was no proper scientific disposal of the solid waste and sorting too was carried out inextremely unsafe and hazardous conditions. It was mostly accomplished by the unorganized sector(ragpickers), who generally segregate only valuables from the waste which give them higher financial gains in the recycling market. Mixing up of the segregated constituents was frequently encountered during transportation due to improper handling and hence it required repeated segregation. For efficient waste management proper segregation of waste should be mandatory at the source so that the waste could go through different streams of recycling and resource recovery.

MSW comprises of organic waste(food and kitchen waste), paper, glass, metal, plastic, textile, construction debris and hospital or bio-medical waste. KRL after the public awareness programmes has been successful in getting the household waste segregated in 'wet' and 'dry' form. The wet waste is the biodegradable or the kitchen waste and the dry waste is the glass, metal, plastic household containers, thick plastic bags such as milk bags, which could be gainfully retrieved and utilized for making new products. The segregated waste collected from homes and hotels etc. by cycle-rickshaws and mini trucks(Chhota hathi) are dumped at the 55 secondary collection sites. It was seen that a large amount of unsegregated waste is dumped at community bins then its optimal recycling is not possible. The waste after collection is segregated manually first and thereafter by machine at Sarai plant and composted.

Manual Segregation

The segregation of waste is a three tier system as follows:

Figure 8: Dumping site

Figure 9: Segregation by ragpickers and labourers

Tier **1- Segregation by rag pickers**

150 rag-pickers are employed by KRL at dustbin sites to sort out and sell recyclable material like plastics, glass, etc. for reuse, thereby reducing the quantity of waste to be collected for disposal at the plant. The remaining waste was then transported in trucks to the Sarai plant.

Tier 2- Segregation by rag pickers at the plant/dumpsite (Figure 8)

Another set of 20 rag-pickers of which 6 are women are employed at the plant/ dumpsite by KRL who separate out clothes and construction material from the waste.

Tier 3- Segregation is executed by labourers employed by KRL in the concrete yard of the Sarai plant (Figure 9).

Reuse/recycle

The segregated material like plastics, glass, etc. are sold for recycling and reuse thereby reducing the quantity of waste to be collected for disposal at the plant.

Figure 10: transportation for recycling

Segregating By Machines

Multilayer packaging from heavy waste items is separated by a blower, thereafter the

wastewas then sieved by trommels into four different sizes. In Trommel-1 45mm sized waste particles are sieved and the residue is transported to waste to energy plant at Gazipur or to a cement plant. The 45mm waste was then sent to Trommel 2. 25mmfollowed by Trommel-3 size-15mm and Trommel-4 size-4mm respectively(Figure 11).The 4mm waste is further reduced in size by shredding and passed through a magnetic sieve to remove the fine pieces of iron and nickel which are then sent for recycling. The non-biodegradable part of the waste is sent for sanitary landfill and the biodegradable waste is sent to the composting plant.

Figure 11: Trommel

1) Recycling of biodegradable waste:

Aerobic composting: In aerobic composting the organic matter in municipal solid waste is biologically converted into the compost or humus in the presence of air in hot and humid conditions. In the Sarai plant aerobic composting is done by KRL from the biodegradable waste by making windrows and watering alternately. The compost formed is distributed to farmers after testing and characterisation free of cost(Figure12).

Figure 12: Aerobic composting

The compost was tested qualitatively and quantitatively for the moisture content, odour, particle size, bulk density, % by weight of C, total Phosphates, total potash, total nitrogen, pH, conductivity, pathogens, As, Cd, Cr, Cu, Hg, Ni, Pb and Zn.

2)Waste Disposal:

Landfills are the most common practice worldwide for MSWs final disposal. Only the non-usable, non-recyclable, non-biodegradable, non-combustible, non-reactive inert waste and the pre-processing rejects and residues from waste processing facilities can go to sanitary landfill sites and in India the sanitary landfill sites must abide by the specifications as per SWM Rules 2016. The waste disposal method of landfills are not supposed to cause health or public safety risks or hazards, as they utilizes the principles of engineering to confine the waste in a minimum surface area with a minimum volume which are covered by a layer of soil (Pappu*et al* 2007).

Before KRL became operational in 2017, HNN had open and uncontrolled dumping of MSW at 2 sites, one at Jwalapur, about 7 km from the city and the second by the side of the National Highway-74, about 8km from the city. In 2012, 37 hectares in the Sarai Village,

about 12 km from the city was allocated for the waste management plant of which 7hectares was demarcatedas a landfill site. KRL in conjunction with HNN is functioning in Sarai presently and is composting the biodegradable waste in the plant and the nonbiodegradable waste is disposed of as landfill at Sarai village site (Figure 13).

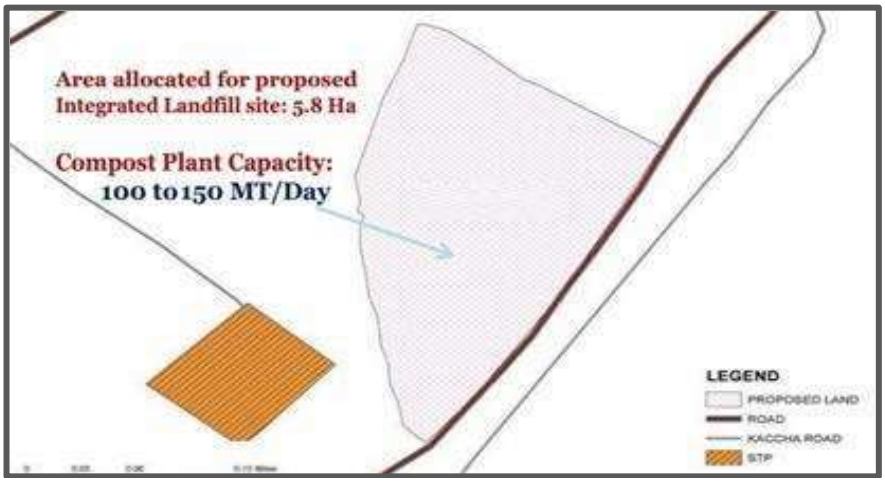

Figure13: Landfill site at Sarai Village, Haridwar

Preparing the landfill site by KRL:

'Landfill' is a term used for final disposal of 'Municipal Solid Waste' on land. The landfill site is engineered with the objective of giving a secured and minimum impact to the environment after disposal of the MSW.KRL has constructed 5.8 hectares of the 7hectare land at Sarai village as a landfill site as follows: Figure:14

i) Removal of the topsoil to clear the site.
ii) Construction of berms (mud ridges)
iii)Installation of drainage systems to remove the leachate.
iv) Installation of double landfill liner (geosynthetic clay sheets and rubble)
v) fill in the nonbiodegradable waste in layers.
vi) Cover the landfill with soil.
vii) Installation of environmental monitoring facilities
a Groundwater monitoring system;
b Gas control equipment;
c Gas monitoring equipment;

Figure 14: Stages in the preparation of the Landfill

Results

Quantitative Analysis

With the maximum plant capacity of 100TDP and only 50tons capacity for processing,the amount MSW processed at Sarai plant from August 2018 to April 2019 was 4,6774 tons and the compost generated was 8,460 tons Table 3. Segregation of multi-layer packaging through rotatory trommel was 64.8 tons.

Table 3: MSW processed at Sarai plant

SN	**Month**	**Total MSW processed (tons)**	**Total compost generated(tons)**
1	August	5976	1087
2	September	3863	765
3	October	3756	858
4	November	3870	784
5	December	5943	984
6	January	5884	987
7	February	5973	1128
8	March	5964	987
9	April	5545	880
10	Total	46774	8460

Table-4 Qualitative Analysis of Compost

Parameter	**Result**	**Specification(** as per schedule iv)
moisture	3.12	15-25.0
Colour	black	
odour	absent	
Particle size	90% Less than 4.00mm	4.00pm
Bulk density	0.49 g/cm'	0.7 - 0.9
Total organic carbon percent by weight	8.5	6.0
Total phosphates (P2O5)	5.7mg/gm 2.61%	0.5
Total nitrogen%	0.43	0.5
Total potash % (K2O)	0.5	1.0
C:N ratio	18:1	20:1
pH	7.5	6.5-7.5
Conductivity	2630 µs/cm	4dsm-1
Pathogen	Nil	nil
As	0.005ppm	10
Cd	0.133	5.0
Cr	8.91	50
Cu	58.84	300
Hg	0.008	0.15
Ni	2.104	50
Pb	903	100
Zn	166.46	1000

Discussion

In 2012 the state government of Uttarakhand decided to adopt to a scientific practice of waste management to improve the sanitation, hygiene and environment for the welfare of the State Thus, the Government decided to create the entire state as a "Bin less State". Based on the growth rate of the cities, higher capacity bins were installed to ensure that the bins don't overflow during festival seasons, when the waste generation is much higher. Municipal solid waste collection was not uniform in the city, but with the public awareness about segregation of domestic waste, collection was made possible in two separate bins by KRL. Inspite of the efforts of HNN and KRL the waste at the secondary collection sites were still unsegregated and contained the organic waste as well as paper, glass, metal, plastic, textile etc which could be gainfully recycled. Most of these containers and bins are of closed type but were often left open attracting stray cows, dogs, cats, rats etc. Optimal recycling of this waste is not possible however, rag-pickers usually sort and sell recyclable material like plastics, glass and metal at a risk totheir health.

The role of rag-pickers is very important in Indian scenariofor MSWM. However, their role in waste management stream has not been given any weightage. They move from one community bin to open dump/landfilling sites in search of recyclable items (paper, plastic, tin, etc.) that can be sold to scrap merchants to enable these urban poor to generate income. Usually, the middle men get the major profit on purchase of recyclable item from rag-pickers on pre-decided rates. Even though rag- pickers save almost 14% of the municipal budget annually, their role is largely unrecognized and they are generally deprived of the right to work. According to an estimate, the rag-pickers reduce up to 20% load on transportation too (Joshi and Ahmad, 2016). Socially the Rag-pickers have been identified as helpers to the society and have been provided with a recognized livelihood by KRL.

Daily transportation of organic waste /mixed waste to the treatment site by container transportation using simple hydraulic system mounted dumper placer vehicles has cleaned the environment and also reduced the risk to human health.Collection and transportation of garden waste, construction waste on pre-fixed days in tipper trucks has also helped to segregate waste at source. Transportation of inorganic and other dry wastes to landfill site by dumper placers has speeded the process of waste disposal with 46,774 tons of waste being processed and 8,460 compost being produced in the study period. A stench emanates from the sanitary landfill site, but the Ambient Air Quality AAQ was within the permitted national limits.

Thus MSWM appears to be fit case for PPP mode for the Indian scenario as ULBs were unable to accomplice the task assigned as per MSWR. The amount of USD 5 billion annually is required to provide adequate MSWM services to Indian Cities like Haridwar (Hanrahan, Srivastava, & Sita, 2006) and this level of finance is be met through PPP in conjunction with KRL. This PPP has been very successful and has moved up Haridwar to 244th rank from an earlier rank of 376 in Swachh Survekshan 2020 (R)of India. On the other hand, power sharing, loss of control of ULBs, cost enhancement, unaccountability, political risks, and lack of competitiveness are major threat.

Suggestions

1.Awareness creation by conducting Sanitation Campaigns for segregation, recycling and reduction and storage of waste at source, by home level composting, waste reduction at source. These campaigns should involve the school children and NGOs so that the message of the campaign reaches the community effectively.

2. Door to door / kerb-side collection with community participation should be on cost recovery basis, minimizing the multiple handling of waste, improvement in the productivity of labour and equipment.

3. With a goal of Zero Waste by 2040, it is essential that every sector must adopt various means and strategies for waste prevention, reduction and diversion. Under a zero waste model, those materials that currently cannot be recycled or composted (roughly 20-30%, depending on the sector), will be redesigned so they can become an input via reuse, recycling and composting. Recognizing the need to re-think waste as a resource is essential now, and in doing so will extend the life of the precious and limited landfill.

4.The effectiveness of public-private-partnership depends upon a well-defined relationship, with clear demarcation of roles, accountability and adaptability of the work dynamics among the various stakeholders are elementary necessities for MSWM.

Conclusion

Segregation of the waste at the source for disposing the organic and recyclable portions bears a significant advantage socially, environmentally and economically and also in reducing the waste. The PPP between the NHH and KRL at Haridwar has been very successful in cleaning the environment, as Haridwar moved up to 244th rank from an earlier rank of 376 in Swachh Survekshan 2020 of India but much more needs to done for sustainably managing the solid waste.Making Zero-Waste as a goal in life, people must necessarily change their lifestyles and practices to sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health.

Acknowledgement

All procedures performed in studies involving human participants were in accordance with ethical standards of the KRL, and informed consent was obtained from all individual participants in the study. Authors are extremly grateful to Mr Ajai Singh MD KRL (H)Pvt. Ltd. and HNN for the generous support towards the successful completion of the study

References:

- Kumari U.(2012): Harappan cities. World history encyclopaedia. https://www.worldhistory.org/article//2cities/
- Mark Kenoyer, University of Wisconsin - Madison. www.harappa.com 2001
- Management of municipal solid waste in Delhi. Central pollution Control Board (2000). http://www.cpcb.nic.in/divisionsofheadoffice/pcp/ MSW_Report .
- Kumar S, Bhattacharyya JK, Vaidya AN, Chakrabarti T, Devotta S, Akolkar AB. 2009 Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: an insight.Waste Manage.29, 883–895.
- TARAN DEOL 11 August, 2020 https://theprint.in/india/pm-calls-for-week-long-garbage-free-country-but-india-is-the-worlds-highest-waste-generator/478889/
- Integrated Solid Waste Management Mushtaq Ahemd MEMON International Environmental Technology Centre (IETC) OSAKA - JAPAN
- https://sustainabledevelopment.un.org/content/dsd/csd/csd_pdfs/csd-19/learningcentre/presentations/May%202%20am/1%20-%20Memon%20-%20ISWM.pdf unep.tie@unep.org Web: http://www.unep.or.jp
  Integrated Solid Waste Management - Sustainable ...
- https://sustainabledevelopment.un.org › csd-1

- Solid Waste Management Rules (2016) http://www.indiaenvironmentalportal.org.in.

- pppinindia.com/pdf/ppp_position_paper_solid_waste_ mgmt_112k9.pdf "Position paper on The Solid Waste Management sector in India" . Ministry of Finance, Government of India. Department of Economic Affairs. November 2009.
- Joshi, Rajkumar; Ahmed, Sirajuddin; Ng, Carla Aparecida (19 February 2016). "Status and challenges of municipal solid waste management in India: A review". Cogent Environmental Science. 2 (1).
  11.Geography of Haridwar
- https://www.haridwaronline.in › city-guide › geograph...

- 12.Census of India Website : Office of the Registrar General ...
- https://censusindia.gov.in

- Kasthala, Sindhuja& BV, Binoy&Lakr, Harshit. (2019). Spatial Strategies for Crowd Management in Haridwar, India. International Journal of Advanced Civil Engineering and Architecture Research. 5. 100-113. 10.23953/cloud.ijacear.421.

- CPCB(2017): Consolidated annual review report on implementation of solid waste management rules 2016.https://cpcb.nic.in> MSW
- Best Practices for Solid Waste Management: A Guide for Decision-Makers in Developing Countries United States Environmental Protection Agency Office of Resource Conservation and Recovery October 2020 https://www.epa.gov/sites/default/files/2020-10/documents/master_swmg_10-20-20_0.pdf

- H.R. Sharma, B Destaw, T Negash, L. Negussie, Y. Endris, G. Meserte, B. Fentaw, & A. Ibrahime, (2013): "Municipal solid waste management in Des-sie City, Ethiopia," Management of Environmental Quality: An International Journal., vol. 24, no.2, pp.154 – 164.
- Nordin, L. Pommer, M. Nordwaeger, I. OlofssonBiomass conversion through torrefaction. Technologies for converting biomass to useful energyCRC Press (2013), pp. 217-244 http://dx.doi.org/10.1201/b14561-8)
- M.J.C. Van der Stelt, H. Gerhauser, J.H.A. Kiel, K.J. PtasinskiBiomass upgrading by torrefaction for the production of biofuels: A review Biomass Bioenergy, 35 (2011), pp. 3748-3762)

- http://scienceindia.in/home/view_article/372
- Status of solid waste generation, collection, treatment and disposal in meterocities (Series: CUPS/46/1999-2000). [Google Scholar]; Pappu, Saxena, &Asolekar, 2007 Pappu, A., Saxena, M., & Asolekar, S. R. (2007). Municipal solid waste management—The Indian perspective. Journal of Indian Association for Environmental Management, 26, 100–108. [Google Scholar]). Therefore, with 5% annual growth in per capita generation landfill area required for disposal of waste could be many folds (CPCB, 2013 CPCB. (2013). Status report on municipal solid waste management. Retrieved from http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdfhttp://pratham.org/images/paper_on_ragpickers.pdf [Google Scholar]
- University of Wisconsin - Madison. See www.harappa.com)
- http://scienceindia.in/home/view_article/372
- https://theprint.in/india/
- CPCB(2017): Consolidatedannual review report on implementation of solid waste management rules 2016.https://cpcb.nic.in> MSW
- Suggestive/Indicative “The National Action Plan for Municipal Solid Waste Management https://cpcb.nic.in/uploads/MSW/Action_plan.pdf
- http://www./ pppinindia.com/pdf/ppp_position_paper_solid_waste_ mgmt_112k9.pdf "Position paper on The Solid Waste Management sector in India" Check |url= value

(help) (PDF). Ministry of Finance, Government of India. Department of Economic Affairs. November 2009.

- Dolla, Tharun; Laishram, Boeing (20 December 2019). "Factors affecting public-private partnership preference in Indian municipal waste sector". International Journal of Construction Management. 20 (6): 567–584. doi:10.1080/15623599.2019.1703085. S2CID 213509856.
- Joshi & Ahmed, Cogent Environmental Science (2016), 2: 1139434 http://dx.doi.org/10.1080/23311843.2016.1139434
- SS2020 Dashboard : Ranking and Awards- Swachh Survekshan. http://www.swachhsarvekshan .org

- Kumar, S., Bhattacharyya, J. K., Vaidya, A. N., Chakrabarti, T., Devotta, S., &Akolkar, A. B. (2009). Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An insight. Waste Management, 29, 883–895. http://dx.doi.org/10.1016/j.wasman.2008.04.011

- Power-driven composting units have been installed (Bhide&Shekdar, 1998)R8in many cities like Indore. In Bengaluru, Vadodara, Mumbai, Delhi, and Kanpur, mechanical composting units of 150 to 300 tons/day capacities were also installed (Sharholy, Ahmad, Vaishya, & Gupta, 2007)R9.