INTEGRATED SOLID WASTE MANAGEMENT OF A MODERN TOWNSHIP- A CASE STUDY

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Abstract

The increasing population and improving standard of living in the towns and cities the society is generating varied categories of solid and liquid waste. In India, Municipal solid waste management is one of the most neglected areas of urban development. The existing infrastructure is far short of the desired levels. The major chunk of wastes generated in various cities and townships remains unattended to causing health hazards to the inhabitants. The present study was carried out to find the major shortcomings in the solid waste management of Chandigarh city along with its impact on the environment. A detailed analysis was carried out regarding the methods of practices associated with sources, quantity generated, collection, transportation, storage, treatment and disposal of Municipal solid waste in the tricity.The data was collected in order to have an idea of the status of management and the experiments were done by collecting Leachate and groundwater samples from the landfill site and its adjacent areas to study the possible impact of Leachate percolation on groundwater quality. After this case study, it was found that there are several lacunas in existing system of SWM in the city in comparison with Municipal Solid Waste (Management & Handling) Rules 2000. Concentration of various physico-chemical parameters including heavy metal was recorded high in the samples also. Although some remedial measures are suggested to integrated SWM approach, the present study demand for the proper management of waste in the township. A Leachate treatment plant is designed for the Leachate treatment and theoretical design considerations of integrated solid waste management approach is suggested along with sanitary landfill construction for the tricity.
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1. Introduction

The words *rubbish*, *garbage*, *trash*, or *refuse* are often used as synonyms when talking about solid waste. Rapid growth of urban population in developing Asian countries in recent years has made MSWM an important issueIndia is facing serious environmental problems in MSWM that is really threatened by a number of problems; some of which include inadequate management, lack of technology and human resources, a shortage of collection and transport vehicles, and insufficient funding. Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls. Therefore, MSWM is one of the major environmental problems of Indian megacities.

Management of solid waste is associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations.

The major thrust of the study was a critical evaluation of the existing solid waste management practices in Chandigarh and to evolve out an integrated municipal solid waste management approach in the township leading to sustainable development. Besides that Leachate and groundwater characterization was carried out to evaluate the extent of pollution which the dumping of the inert waste/reject and the organic untreated waste at the dumping ground is causing. The sampling plan involves weekly sampling in the month of March and April from the landfill and the nearby areas for the groundwater.

Chandigarh city

Chandigarh is only planned city in India with a population of 1,064,711 (2010), and geographic area of 13,256 km2. The City Chandigarh was declared a Union Territory in the year 1966 with joint capital of both the states of Punjab and Haryana. It is situated in the foot of Shivalik hills. The area of Union Territory of Chandigarh is 114 sq. km. only with 22 villages falling in the jurisdiction of Union Territory.

With the formation of Municipal Corporation Chandigarh in the year 1994 (with 20 wards) with its jurisdictional area of 79.34 sq. kms.; the functions of original works & maintenance

for roads; water supply, sewerage, storm water drainage, solid waste Management and fire wing were transferred to Municipal Corporation, Chandigarh. The city Corporation of Chandigarh has been making all out efforts to devise foolproof methods to organize the management of MSW in an efficient manner. Being a planned city the whole city has been divided into four zones as per details given in table and the supervisor has been made the in charge of the Zones for the purpose of Sanitation and refuse removal services.

There is only one designated dump yard consisting of 45.11 acres of land which is situated in Sector 38 near Dadu-Majra Labour Colony. A MoU has been signed between CPCB, CPCC and M.C., Chandigarh to set up a Model Facility for Demonstration of Municipal Solid Waste for Implementation of the Municipal Solid Waste Rules. 1st phase of Project has already been completed except construction of some Sehaj Safai Kendra. 2nd phase of capping and covering of old landfill site and development of new landfill site is also in completion phase. Waste Processing Plant for commission of Municipal Solid Waste into RDF has also started. Municipal Corporation, Chandigarh is collecting daily around 360 tonnes of municipal waste which goes to the to the Processing Plant at Dadu Majra which process the waste and convert that into RDF (Revised Derived Fuel) and dump the rejected into Dumping Ground at Dadu Majra.

2. Materials and methods:

This study was carried out to estimate the waste generation, collection, transport and transfer, processing, recovery and disposal system to find the shortcomings and problems the city is facing due to these activities and to evaluate a better approach for the same.

Waste composition analysis

The solid waste composition of the city was analysed from the secondary data collected from the garbage processing plant at the city. Before the set up of the plant the three basic Steps followed for the Disposal of Municipal Solid Waste in Chandigarh were dumping, spraying of EM Solution and levelling. Dumping is the primary step of Waste Disposal. Everyday around 280-285 vehicles full of Municipal wastes were brought to this site for dumping. Thereafter, the ground is treated with effective Microorganism Solution (E.M Solution).This

is to prevent flies, mosquitoes and other insects. The last step was levelling off the ground. The heavy chain dozer compactor vehicles were used which compress the waste, followed by which oil and grease was sprayed on the land. The waste was then covered with a layer of Construction and Demolition Waste which is about 2 feet thick as per MSW Rules, 2000.

In the current practice door to door collection of waste take the waste to Sehaj Safai Kendras and from there the Municipal vehicles carry waste to the processing plant at nearby locality of the dumping ground.

Leachate and groundwater characterization.

The analysis and testing of samples for various parameters was done in the the laboratory to study the environmental impacts of disposal of waste in the dumping ground..The physicochemical parameters associated are pH,colour,alkalinity,hardness,total dissolved solids,chloride,potassium,sodium. The presence of heavy metals was also tested using atomic absorbtion spectrophotometer.

Details of the Site location for sampling Leachate and groundwater samples

The dumping ground near processing plant receives inert and other organic unacceptable matter from the Green tech processing plant. It is a non engineered landfill located in the vicinity of Dadu Majra village. It is situated in Northwest Corner of Chandigarh and is at a distance of 5 kilometres from PGIMER, Chandigarh and 6 kilometres from Inter State Bus Terminal of Chandigarh. The dimensions of Dadu Majra Colony are 1.6 kilometres and 1.1 kilometre i.e. 1.76 square kilometres area. It inhabits a population of 16,500 having 8800 males and 7700 females (census 2001). The residential area of the Dadu Majra Colony was divided into area-1 to area-9, which had 72 lanes and 64 parks. Apart from these nine areas there were 10 streets, 7 markets, a government school, a dispensary and 2 jhuggis (Vijay colony 1 and 2). There were 5 public taps and 35 hand pumps in Dadu Majra Colony. Out of 5 public taps two were in market, 1 each in Jhuggis (Vijay Colony I), Dispensary and Government School. Out of 35 hand pumps 7 were in parks, 4 in lanes, 6 in market, 2 in Government School and 16 in Jhuggis. Only 20 hand pumps had handle and the sanitary condition of 12 hand pumps was very poor.

The Leachate from non engineered landfill was collected twice in the month of March and April from the ground surface where brown coloured liquid accumulated towards the village end. In order to check the contamination due to Leachate the samples of ground water were collected from different locations from nearby hand pumps, tube wells etc.

3. Results and discussions

Estimated waste quantity and composition

The results from the study reveal that the per capita MSW generation rate is 0.39 kg/capita/day. However, 370 t/day of waste goes to processing plant for processing from which the sand, soil and organic matter and inert material is thrown in the dumping ground. The physical and chemical characteristics of the waste were determined for estimation of the moisture content, ash content, pH and the organic content. The secondary data collected from Green tech fuel processing plant as presented in the table 3 and 4

Table 1 : Physical analysis of the Municipal solid waste sample collected from Belt conveyor-09 of processing plant

S.no.	PARAMETER	RESULT
1	Material passing through sieve (% by mass)	89.2
2	Sand, Soil and organic waste (% by mass)	94.9
3	Inert material • Glass (% by mass) • Grit ((% by mass) • Metal ((% by mass) • Plastic (% by mass)	 • 2.9 • 0.8 • 1.2 • 0.1

The inert material and organic waste is thrown at present in the landfill.

Table 2: Average chemical analysis of solid waste in the city

S.no.	Parameter	Results
1	Moisture content %	5.63
2	Ash content %	24.40
3	Organic content%	78.94
4	Gross calorific value(cal/gm)	2911
5	Chloride (% by mass)	2.80
6	Bulk density (gm/cc)	0.20
7	Volatile matter(% by mass)	23.68
8	Silica as SiO_2 (% by mass)	1.33

Leachate and groundwater characterisation

The results on phsico- chemical parameters for the Leachate sample and the groundwater samples are presented in the table 5 and table 6 respectively

Table 3: Physico-chemical parameters of the Leachate sample

S.no.	Parameters	Units	MSW landfill Leachate sample
1	pH	-	5.2
2	Colour	-	Light brownish
3	EC	-	15560
4	Chlorides	mg/l	9440
5	Total hardness	mg/l	180
6	TDS	mg/l	7968
7	Alkalinity	mg/l	118
8	Sodium	mg/l	13
9	Potassium	mg/l	8
10	Sulfate	mg/l	32
11	COD	mg/l	2783
12	Magnesium	mg/l	23.9
13	Calcium	mg/l	67

Table 4: Concentration of heavy metals in the Leachate sample

Parameters	Leachate Concentration Of Heavy Metals
Lead	1.6
Copper	0.19
Zinc	5.1

Table 5: Results of groundwater characterization

S.no.	Parameters	S1	S2	S3	S4
1	pH	6.2	6.9	7.1	6.3
2	EC	749	669	754	680
3	Chloride	92	85	115	162
4	Total hardness	468	383	408	298
5	TDS	378	467	533	446
6	Alkalinity	145	217	132	125
7	COD	10	12	25	8

DISCUSSION

- ***Waste Generation In The City***

The population of the city was 1,06,4711 in the year 2010.Therefore; the quantum of the waste generated was 360 t/day. Out of which, major amount is of biodegradable substances (40-50%) consisting of organic matter like vegetable peels, and leftover foodstuffs. Combustible fraction accounts for 20-25% of waste and rest is the inert fraction which includes sand, dust, glass and others.

- ***Waste handling, collection and storage***

The city corporation has provided garbage collection containers at strategic paints. But the results seen were different from what was expected. The residents used to through the waste outside or near the bins instead of the putting it inside the bin. To cater this problem an experiment was done by the Municipal cooperation of Chandigarh that was called "Bin Free Collection."For the purpose of collection removal and storage of Municipal Solid waste, the Corporation allotted about 1/5 of the city area to private entrepreneurs for providing sanitation services. It has also engaged 373 Nos. of safaiwalas through outsourcing. In this experiment instead of placing lots of dustbins in the same sector, one or two places were earmarked where bins were placed. The residents of the area were asked to arrange the disposal of their house hold waste at the Sehaj Safai Kendras by engaging cycle carts for House to-House garbage collection on cost recovery basis. A survey done by A. Khajuria et al revealed that the collection frequency of MSW shows that 42.7±5% of houses are paying for solid waste collection services to local sweepers, and 45.6±3.5% are willing to pay for the improvement of solid waste services

- ***Waste transportation***

Removal of garbage is a very important aspect of SWM and the method of transportation is crucial. In Chandigarh, from the Sehaj Safai Kendra the waste is transported to the processing plant by High speed Vehicles. They are Called Dumper Placers. These vehicles are provided with shutters so that the waste does not fall off while transporting. The Vehicles keep on moving from 8 am till 5 pm and collect the filled up bins from the sectors and placing vacant bins instead.

- **Waste processing**

The processing of waste helps in achieving the best possible benefit from every functional element of the SWM system. In Chandigarh an effort is being made for the processing of the waste. In a public-private partnership venture between the Municipal Corporation of UT Chandigarh, and the Jaypee Group of New Delhi, a major municipal solid waste processing plant, named as Jaypee's Municipal Solid Waste Processing Plant, is being set up in the city's outskirt at a cost of Rs.23 crore.

- **Waste Disposal**

In Chandigarh, as far as disposal is considered, the remaining waste which is not accepted by the plant and the inert material is dumped into a 22 years old dumping site located in Dadu Majra. It is a 45-acre open non engineered disposal site where no prior efforts have been done to ensure that environmental protection. The plant is producing nearly 18% of the inert material after producing RDF pellets which is used as a fuel in broilers etc.

Integrated solid waste management system in the Tricity:

In order to have an integrated approach of waste management in the city the existing Green Tech fuel plant should be augmented with the facility of processing of the organics through various methods instead of dumping it into the ground. The proposed technology options available for processing the Municipal Solid Waste (MSW) are based on either bio conversion or thermal conversion. The bio- conversion process is applicable to the organic fraction of wastes, to form compost or to generate biogas such as methane (waste to energy) and residual sludge (manure).The present processing plant can be augmented with aerobic, anaerobic and vermi-composting. However, the thermal conversion technologies are incineration with or without heat recovery, pyrolysis and gasification, plasma pyrolysis and pelletisation or production of Refuse Derived Fuel (RDF). Following facilities are to be considered during preparation of the layout of proposed project.

- RDF plant with collection & Waste Storage area
- Compost plant with collection & Waste Storage area
- Incinerator
- Landfill area
- Area for Green Belt Development
- Other infrastructure such as Internal Road area, Parking Area, Administrative building area, Workshop area

Leachate and groundwater samples analysis

The results portray that the pH varied slightly on the alkaline side and the chloride concentration was also high in the non engineered dumping ground of the tricity.This deplete the water quality of the Dadu Majra colony and the nearby areas. The presence of heavy metals in the water sample and the Leachate is a cause of concern for the corporation as they are toxic to the residents of the village. The high value of COD is also recorded in the

samples of Leachate and water due to the dumping of the rejects and inert in the ground which are not acceptable by the processing plant.

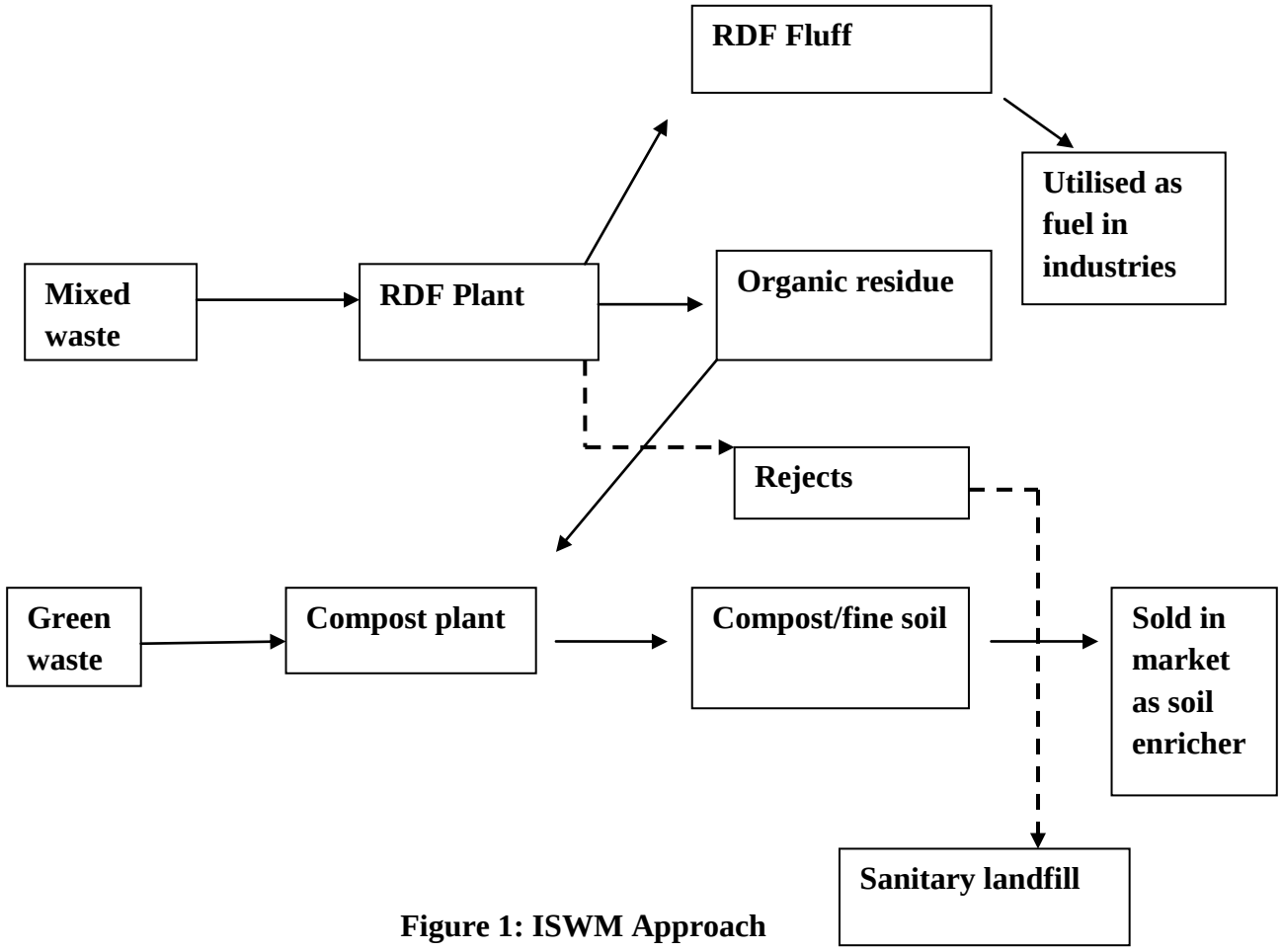

Figure 1: ISWM Approach

Effect of Distance and Depth

The extent of contamination of groundwater quality due to leachate percolation depends upon a number of factors like leachate composition, rainfall, depth and distance of the well from the pollution source. Water samples collected from different depths and distances were analyzed for this study.

Interestingly the water contamination drops fast with depth up to 30 m and further percolation of leachate becomes gentler as can be seen in the case of tube well dug at the depth of nearly 30m or more. Water sampled from the well situated close to the landfill site was found to be more contaminated than that of the well situated farther away. It obviously follows from the

fact that the gravitational movement of the viscous fluid, leachate is hindered due to the mass of the solid soil matter. With increasing time the viscous fluid penetrates deeper and spread all over a longer distance. Although increased levels of few pollutants in groundwater may also be contributed by some nearby activity. The TDS, TOTAL hardness decreased along with depth and distance as well.

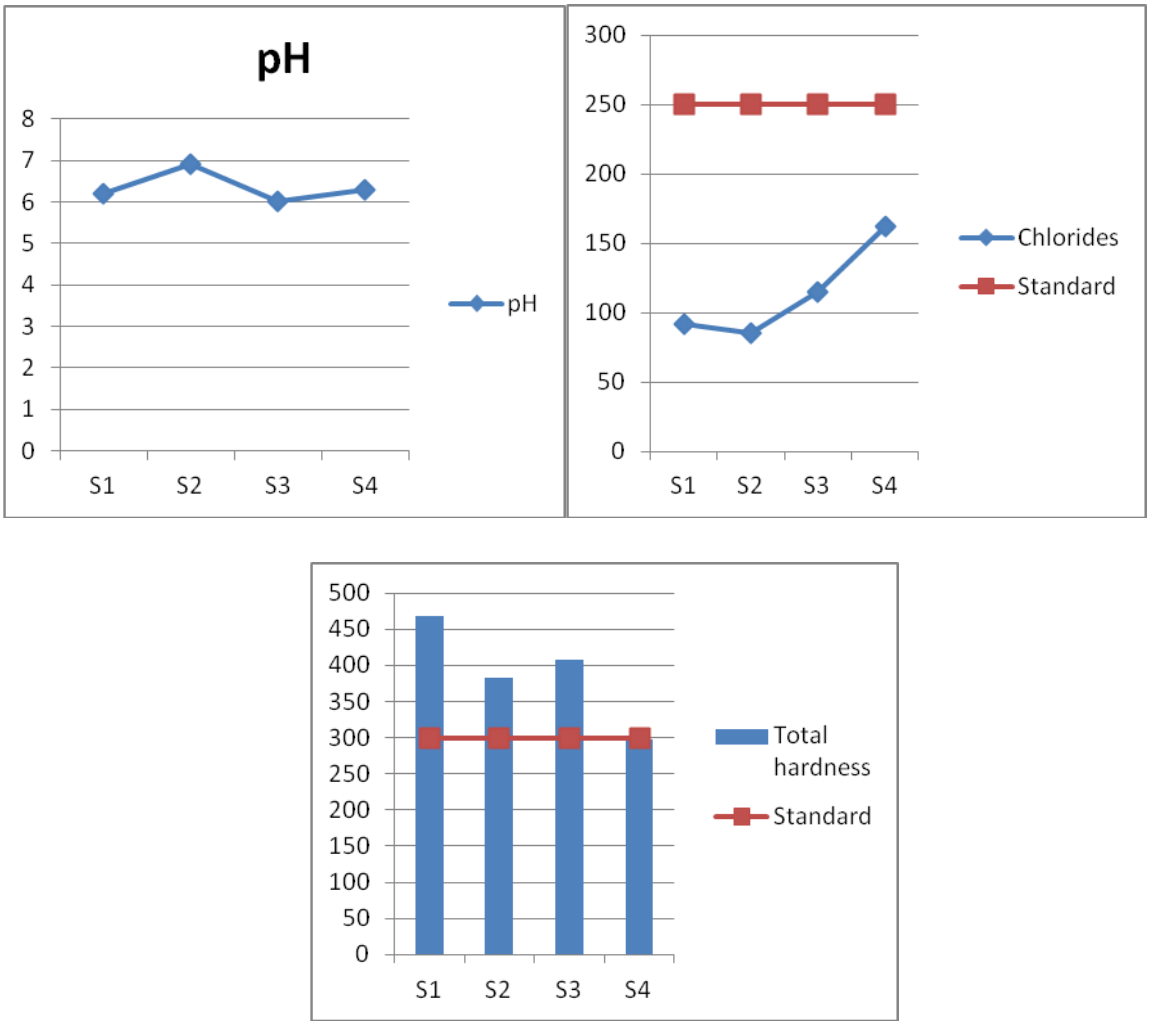

Figure 2: Effect on groundwater parameters due to Leachate percolation

Proposed design for Leachate management system

The possible Leachate treatment methods to be considered may refer to a common treatment with municipal wastewater and separate treatment of all or some of the wastewater fractions, depending on Leachate load, and wastewater treatment plant capacity .Treatment of Leachate must meet the water quality standards set by regulatory authorities and ensure a successful and efficient treatment, having in mind that the characteristics of Leachate undergo spatial and temporal variations

Sequencing batch reactor

The sequencing batch reactor (SBR) process is a form of activated sludge treatment in which aeration, settlement, and decanting can occur in a single reactor. SBR is quite common solution for on-site leachate treatment. If applied together with further polishing steps, it allows significant decrease of contaminants' concentrations in the leachate. The process employs a five-stage cycle: fill, react, settle, empty and rest. Waste water enters the reactor during the fill stage; it is aerobically treated in the react stage; the biomass settles in the settle stage; the supernatant is decanted during the empty stage; sludge is withdrawn from the reactor during the rest stage; and the cycle commences again with a new fill stage. SBR systems are capable of producing a high-quality effluent.

In an integrated management approach the treated Leachate from the reactor can be applied to shredded MSW that is to be composted and used for intermediate cover material in the landfill. Application of Leachate to the shredded MSW provides the moisture needed for optimum composting and reduces the volume of Leachate through evaporation. The excess remaining Leachate is used in wetlands and the effluent from constructed wetlands is passed for spray irrigation on the grass covered landscape at the landfill

4. Conclusion

This study was carried out in order to establish up-to date waste composition data for local solid waste authorities. The studies presents that the dumping ground in the city which is a non engineered landfill is causing environmental impact and the solid waste management system in the city need to be considered wisely. Seggregation at the source is desirable and the two bin system should be started at the household level.

Door to door collection system should be started with covered motorized vehicle having two compartments-one for the organic waste and other for the rest of the waste. The

characterization of the waste should be done on a regular basis from 10 different pre locations of the city. To have an integrated processing system in the tricity the existing RDF facility should be expanded or augmented for the processing of organics through composting /biomethanation. All the organic waste from the household/mandi/hotels/markets should be sent to the composting facility instead of current practice of sending it to the dumping ground.

The existing eight acre land facility is not adequate and action should be taken to acquire at least 50 acres of additional land for further use. An engineered landfill should be made operational in the city as soon as possible. A steering committee should be set up for preparing action plan, overseeing the implementation and revising the action plan from time to time. The need of the hour is to educate citizens of the tricity.The residents welfare associations, schools, colleges and other agencies need to be talking about the issue of garbage disposal big as a part of their daily agenda.

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