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Regulation and Transportation of Municipal Solid Waste in Urban Area

Yash Patel[1], Shikha Rangrej[2]
[1]*Post Graduate Student, Town and Country Planning,*
Sarvajanik College of Engineering and Technology, Surat – 395001
[2]*Adhoc Professor in Faculty of Civil Engineering,*
Sarvajanik College of Engineering and Technology, Surat – 395001

Abstract
In urbanized county, solid waste management is elemental key to environmental sustainability. Environment pollution, odor nuisance, climate change and other acute health related problems are associated with unscientific management of solid waste. The current status of municipal solid waste management in India is mentioned which helps to scrutiny existing management process and identifying the challenges and constrains of solid waste management. New proposed plan leading to effective solid waste management reduce time, effort and cost for the process. Population density, insufficiency of financial resources, social attitude, climate and lack of training in modern solid waste management service all have contributed to causation of this critical scenario. The study includes type of waste produce, generation of waste, on site storage, transfer, transportation, route of transport, methods of MSW, GIS images, processing and recovery, ultimate disposal, waste minimization and management treatments as composting, recycling, incineration etc. Every waste management step induces greenhouse gas emission hence it's necessary to develop methods for reducing environmental impact. The study strongly recommends that government should consider initiation of waste to energy restrain the risk of waste management and concurrently solving the energy need of the nation.

Keywords*: Cyber - physical systems, intelligent systems, GIS, vehicle routing, greenhouse gases, energy, municipal solid waste.*

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I. INTRODUCTION

Solid waste is the major problem in developing countries. Lack of proper waste management generates surrounding environment issues, air pollution, and climate changes. Solid waste is those wastes that are unnecessary and unhygienic generated by the consumption, production and also from human and animal activities. There are many challenges to achieve the proper and effective management like disposal, route of the waste disposal, place of disposal etc. Amount of waste generated indirectly depends upon the population growth in the developing country. Waste generation are larger if the population is larger and therefore management must need property has to be developed. We have to find out the proper system that ensure about the management of this waste. Management of solid waste also depends upon the awareness of people and the knowledge about the increasing problems due to this improper waste generated in the daily life period. In this paper, we discuss about the processes and the management systems that are so affected in the waste management process and we will get the idea about the system that are used in the route assign process of the waste from the busy daily life routes like cyber physical system and the gas systems and also covered that how the fuel consumption during the process of transfer of solid also affects. Air pollution is also the major aspect in this process, not only due to the municipal solid waste but also due to the fuel consumption and releasing the gases that affects the human health. Solid waste also generates the greenhouse gases that include the many types of gases which are the reasons of the air pollution and the climate changes. Such a method like open public dumping of any type of solid waste in open space is a big issue in the country. Improper management of the waste on the road create so many problems in the manner of road conduction and aesthetic look of the city and also spread odor around the area due to burning of the material and if there are non-decomposed material that generates the hazardous gases, harmful gases and also generates greenhouse gas that directly affect the climate. Some waste management technologies provide energy from the waste by land filling gas recovery, landfill bioreactors, incantation, aerobic composters, and anaerobic digesters developed in some of the country to manage the waste effectively. Therefore, we need the large amount of land for the application of all this processes.

II. URBANIZATION

Urbanization is directly linked to the solid waste generation. India is high populated county of having climatic, geographic, ecologic, cultural and social diversity with 377 million (census of India, 2011) people. The population in urban areas has intensified from 18% to 31.2% from 1961 to 2011 respectively (census of India, 2011). In India, the rise in population growth, reduced opportunities in rural areas, unwanted immigration majorly leads to urbanization. Which is one of the major reasons of becoming solid waste management an acute problem? The study done by the US public health service (USPHS) reveals that there are around 22 human diseases due to inappropriate solid waste management.

III. GENERATION OF SOLID WASTE

The planning commission report discloses that 377 million people in India generate 62 million tons of solid waste per annum. According to the study it's expected that the population of India would be about 1,823 million by 2051 and there will be generation of about 300 million tons per annum of municipal solid waste. It will require around 1450 $km^2$of land for disposal of the waste.

Study proves that small cities have been more careful about generation rate of MSW. The quantity of MSW generated in India in 2000 & 2011 is shown in table. In cities the rate of waste generated is much lower than smaller town.

Majorly the municipal solid waste is generated from the residential body, commercial waste (from market, hotel and restaurants), clinical waste, institutional waste (from school, university, government college), construction and demolition waste and municipal service waste like drain cleaning, street sweeping. The agricultural residue, cattle manure and poultry dropping also generate massive solid waste. From which only 50-60% of these are collected on daily basis, remaining are left to decay on streets and roads. Therefore, it's tough to determine generation rate of MSW. Due to inadequate data regarding waste generated per capita, insufficient information on waste characteristics, different outcomes from various projects, it's strenuous to estimate the land requirements and adopt appropriate disposal techniques.

Plastic is very harmful for the environment even though people are in favor of using it because of its light weight, non-breakable and economic nature. Plastic become more dangerous to human health because it cannot be incinerated or dumped because it produces harmful noxious gas and non-degradable nature. Due to enhance in usage of plastic, there is generation of 3.5 megatons plastic waste at the end of 2003. In India 90% of the plastic waste is recycled. The recyclable plastic waste is collected at regular time interval by rag pickers, who use these wastes in manufacturing of new materials.

IV. COMPOSITION OF SOLID WASTE

The primary composition of municipal solid waste is given below. Somehow there can be variation according to the surrounding locality, personal sanitary conditions, cultural attitude etc. The solid waste can be either biodegradable or non-biodegradable.

- **biodegradable waste:**

- Ash, food scraps, vegetables, worn out clothes, leaves, wood, metallic materials, used cartons and cardboard boxes, charcoal

- **non-biodegradable wastes:**

  - Recyclable material: paper, glass, bottles, cans, certain plastics, polythene bags, rubber items
  - Inert matter: dirt, debris
  - domestic hazardous waste (household hazardous waste) and toxic waste: e-waste, paints, waste medicine, chemicals, light bulb, fluorescent tubes, fertilizer and pesticides containers, batteries, shoe polish.

The biodegradable waste material can be useful after their conversion to bio fertilizers or as a source of green energy. In India there is around 40-60% compostable, 30-50% inert and 10-30% recyclable solid waste. According to Nigeria report, Indian solid waste is consisting of nitrogen (0.64 ± 0.8) %, phosphorus (0.67 ± 0.15) %, potassium (0.68 ± 0.15) %, and can ration (26 ± 5) %.

V. COLLECTION AND STORAGE OF SOLID WASTE

The proper collection technique of waste can be very effective in management of MSW. In India major portion of wastes are not properly collected, stored and disposed in delegated place for ultimate disposal because of insufficient awareness, lack of commitment and motivation. Normally the collection capability ranges between 70% -90% in major cities where as in rural area it's below 50%. The study reveals that the body controlling solid waste management in urban area spends around rs.500-1500/ per ton on collection, transportation and treatment of solid waste. Mostly people ignore the source storage & separation of organic, inorganic, hazardous waste. For awareness and to encourage people, government authorities organize programs. Such awareness programs are done to educate people about the effect of waste and garbage, to teach them how to manage wastes, how to segregate solid wastes into biodegradable and bio- no degradable at household level.

For the collection of solid waste there is door to door collection system from the source (e.g. House). The residents keep their wastes in plastic or metallic container of various sizes and shape in their house. The personnel collecting waste collects the container and dispose it in the van then return the empty vessel to the resident. The wastes collection van gathers the waste at regular basis. These wastes are collected by NGOs, cobs, and city authorized body. Then the wastes are transported to the nearest secondary disposal site (suds). A secondary disposal sites (sdss) could be an open space or roadside area or large concrete bins. The sdss plays vital role in managing wastes.However, in India the position of sdss are very troublesome. From the sdss wastes are taken to the ultimate disposal site. The ultimate disposal can be performed only at certain places according to the space available, population, accessibility and other factor. In India large amount of population is unable to obtain door to door waste collection service only few wastes are actually collected. Insufficient resource (like manpower and budget) are the main reason that huge population is not getting the facility of collection. Where door to door collection service are not possible, house dwellers or servants takes the wastes to the nearest community bins or secondary disposal sites on their own.

Furthermore, various types of community bins having different size and shape are arranged by city authorities. They are situated on roadside at persistent interval. These bins are normally made of concrete, steel or masonry in rectangular shape. There is practice of two bins for collection. One blue and other green. Blue for the non-biodegradable waste and green for bio degradable waste.

VI. TRANSPORTATION

The management becomes more effective when after collecting the waste, it's transported to suitable ultimate disposal site. Proper transportation of solid waste reduces effort, time and cost for government authority. In India the most common vehicles used for the transportation of municipal solid wastes are compactors, dislodging vacuum tanker with tractor, trailers, dumpers, open truck or tipping truck, tractor with trolley etc. In smaller cities bullock carts, hand rickshaw or truck with 5-9-ton capacity are used. The maintenance of these vehicles used in transportation of solid waste management is performed by bulbs (urban local body) though they perform only minor repairs.

The NGOs, cobs collect the waste from the source but to transport them from secondary disposal site to ultimate disposal site is the responsibility of city authorized body. Required staff is appointed with each vehicle for transportation process. There is allotment of fixed schedule and time for collection and transportation. It's mostly in daytime. The cpcb (central pollution control board) have prescribed some rules:

1. The storage facility arranged by local authorities should be daily attended for cleaning garbage.
2. Transportation and collection vehicle should be designed as such it can perform multiple handling of garbage, prior to final.
3. Vehicle used for primary collection like door to door, light cut vehicles are used to minimize strain on the workers.

None of these rules are followed properly. The vehicles used are not in good working condition, they have leakage and pungent smell of waste. Also, the city authorized body is not having sufficient numbers of vehicles and staff to perform this operation effectively. Thus, the situation is very disappointing. There is some various proposed system with modern technology to improve transportation process. They are as follows:

6.1 GIS SYSTEM

The effectiveness of collection and transportation process is based on experience of driver of operating vehicle. Due to lack of routing plan there may be complication regarding the process. Most of the MSW management costs are used for fuel consumption and wages. To reduce that switching the positions of waste collection bin, exchange of size and number of bins, alternative route investigation such amendments are done.

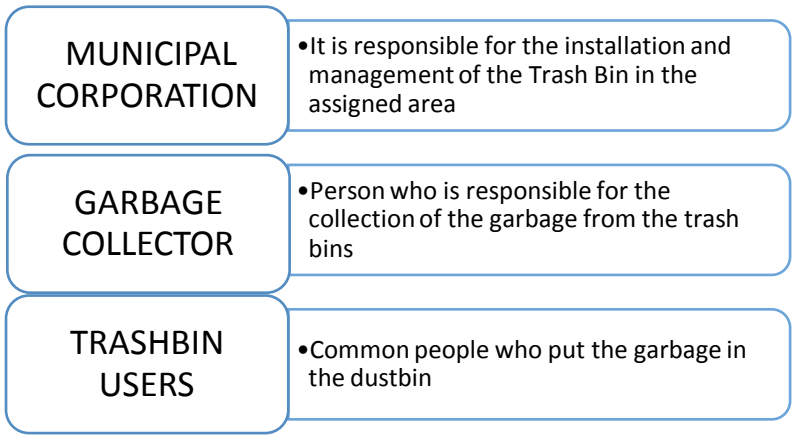
The Geographic information system (GIS) is strong tool to plan truck routes. It stimulates the network and decide route for collecting truck. This ultimately leads to reduction in travelling distance, time and cost also. The GIS track the number of bins in the route and estimate time requires emptying each bin. The GIS provide map including street's directions, restrictions, traffic and turns. It should be updated regularly as there may be possibilities of change in bin's location according to availability of waste collectors. The main target of this GIS is to modify, control and manage the process of transportation with maximum efficiency.

6.2 CUSTOM BLOCK CHAIN BASED CYBER PHYSICAL SYSTEM:

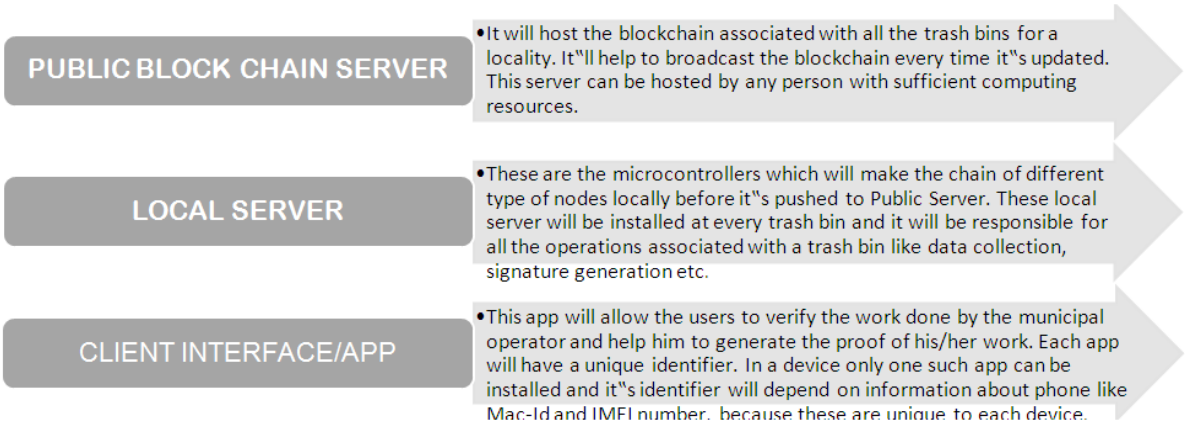
According to the recent situation in India regarding MSW management there is need of smart waste management system to prevent further exacerbation. The cyber physical system has block chain based verification system that ensure the working and usage of trash bins. This is intelligent android app system inspired by current global trend of Smartphone. It keeps record of use of waste disposal place and also verifies that place is properly maintained by a municipal office that is in charge of that particular area. The data helps to analyses the behavior of people and spread of diseases due to unhygienic surroundings.

The system is designed in such a way that every step in the collection and management of waste is checked, which will make the implementation more efficient and allow people to engage in waste management. The stakeholders of our proposed system are as follows:

LIST OF STAKEHOLDERS AND THEIR ROLES



The components associated with our system are as follows:



TYPES OF NODES IN BLOCKCHAIN:

1. Node Type A [Data Entry Node]: This type of node stores the state of the trash bin at a particular time stamp. The state includes the humidity level, depth and other factors of trash bin. This type of node is created whenever trash bin is used. The block of these nodes will be pushed to the public servers.
2. Node Type B [Half Verification Node]: This type of node will be created when number of type A nodes cross a certain threshold value and it is validated by municipal worker. This node will store the details of the municipal worker who has verified the block of nodes (type A).
3. Node Type C [Full Verification Node]: This type of node is created when the municipal worker has cleaned the dustbin and the trash bin has been verified by the local user who is part of the network. This node stores the status of cleaning of trash bin.

The nodes proposed above will be generated at some level of verification. Here, we consider that verification will be required once the sensor readings in the trash bin exceed a certain threshold level. There are three verification states in our method and the characteristics of the verification stage are as follows:

1. Block Filling Stage (Pre-Verification Stage): At this stage, the trash bin will be in working condition and any time it is used, its state will be recorded. No verification is required at this stage.
2. Half Verification State: When a municipal worker comes near to the dustbin and cleans it, Block can reach this state. Here, the municipal worker has to show the local server as well as public servers' evidence of his job, which will be achieved by solving a hashing problem.
3. Full Verification State: When any person is in near proximity, Block will reach this state and make sure that the trash bin is clean. Here, to validate the work of the municipal worker, person has to solve hashing problem and then person may give the rating [0 or 1] that will be stored in node type C along with the application identifier through which it is validated.

The backbone of our work is the block chain part. As follows, the whole procedure is carried out. It is in the block filling state during the installation phase or when the trash bin is completely empty. The ultrasound sensor, humidity sensor and other sensors record the reading of the state of the dustbin when the user puts the garbage in the dustbin. The reading which is taken at particular time stamp which is reflecting the state of the dustbin is stored as an object which we are calling a node of type A. Another node is also generated and added to a list on the local server when the dustbin is used a second time. Once we have reached the maximum threshold or dustbin is filled in the list, we can add only a limited number of nodes, the entire list is packed as a block that cannot allow any other type A node. At the same time, a type B node will be generated which contains the id of all type A nodes that are now packed together as a block. A text message will be sent to the local municipal corporation on the formation of the block to go and clear the dustbin and this block will be sent to the public block chain servers and a record of the block ID that is pushed to the main server will be presented to the microcontroller. The android app, which is a component of our system, will be linked to the dustbin microcontroller through an access point that is hosted by the microcontroller of the dustbin when the individual reaches the near proximity of the dustbin on site or we can tell our local server. In order to generate the hash that is smaller than a specified threshold, municipal worker will create the hash from the hash of the previous node A and the nonce at run time. We will make sure that the challenge is difficult enough that it will be done before the dustbin cleaning is completed. But if a worker is allowed to solve the challenge but the dustbin gets cleaned or it reached to its initial state, the microcontroller can submit the nonce which will help to build the suitable hash for which phone is working and we can claim the block has completed half validation and the same time one node of type B is appended to the main block chain in public servers. The local dustbin still retains its ID. It will clear the status in that block of all the nodes. Once the dustbin is used by some other person from the locality and comes in the nearer range to use the dustbin and verify the municipal worker's job. It must also solve the hash problem for the type B node to do so. Once it resolves, node C will be connected to the block chain's last added block and the block will achieve maximum validity and another instance of the block will be instantiated locally at the microcontroller.

VII. DISPOSAL METHODS

- **RECYCLING**

It is the processing of waste into the similar other product first of all we have to separation of solid waste in proper manner recyclable and organic waste are separated collected waste from certain area by the vehicle and dumped at the landfill side and the people have to separate the reusable product. At the society level two bins are provided for separation of waste segregated waste should be carried out by the rag pickers

- **DECOMPOSTING**

According to the India place 40 to 60 percentage is compostable and that consists of NPK. Moisture content in this waste is 40 to 50 percentages. This composting garbage is useful for the agriculture point of you and it is considered as a low cost product than artificial products if this waste not composed in proper manner the decomposed material generates the gases and this all decomposed waste also affect the ground water surface which water is normally used by the local people for many purposes like bathing, washing, farming and drinking. Composting process are not so useful for the solid waste management point of view because the health and the hygiene aspects are absent in this process

- **LAND FILLING**

Land filling is one of the systems of the waste management and it's connected with many aspects. In this method large area of land is must require for the waste management. Other connected process with this is excavation, loading off waste, unloading at landfill site, compaction of waste in layers, leachate and others. Landfill process of waste management is the process which generates the large amount of greenhouse gas and its effects the climate.

- **GREEN HOUSE GAS FROM LANDFILLING**

In the landfill operations GHG gas is generated and that distributed in the direct GHG emission in which the gas generated through their own waste disposal operation and in indirect GHG emissions gas generated through the fuel consumption of transportation vehicle, operation machinery, and electricity consumption. Landfill gas (LFG) also the outcome of this landfill process. The landfill concerns the most complex operation where an aerobic micro-organism degrades the organic matter in the form of biogas this gas contains mainly co2 and ch4 which are the most effective factors in the generation of GHG this co2 and ch4 compound estimated by the land gem model.

Angola's total GHG emission were 252.09 million of mtco2eq, totalizing 0.52 percentage of global GHG emission in 2014. The energy sector gives the idea about the source of GHG in Angola, with 49.04 percentage of emission from energy emissions, 37.04 percentages from the land-use change and forestry, 11.07 percentage from agricultural, 0.9 percentages from the waste, and, 0.6 percentages from industrial processes.

Emission was calculated using the method generated by Chan and lo and IPCC guidelines for GHG inventory. First equation used for the GHG emission produced by transporting municipal solid waste and second equation used for those produced by the waste treatment plant.

- **INCINERATION**

Municipal solid waste burnt directly in the presence of oxygen at 800 c temperature. Due to the combustion transfer 65 to 80 percentage of heat of organic matters into the water that is useful in the generation of power. Incineration is the process that decrease the amount of waste in 90 percentages by volume and 75 percentages by weight and these also generates the electricity during this process. In India, this is not effective method of waste management because of high moisture content low calorific value of waste for combustion is not sustainable.

VIII. ENERGY RECOVARY FROM WASTE

Cities in growing countries have effective municipal solid waste management. Previous years landfill had been most used system of waste disposal process in going countries. Some countries already banned this landfill method, it occupied large amount of land and create some environmental issues. Incineration process, combustion of waste is widely used nowadays. This process also generates the toxic gases and waste left out after the combustion. If we used proper designed gasifies like pyrolysis process, this method works on the low contaminated emission, and low amount of waste after combustion is left out

- **ENERGY FROM WASTE IN INDIA**

In India, 30 million ton of solid waste generated through household and it has potential to generate 1000 mw power through it. In India, the waste has the high percentage of degradable organic matters between 35 percentages to 75 percentage waste compared to 12 percentages to 15 percentages of USA and UK. From this we will get the idea about the potential of our garbage to generate a very high level of energy from it.

IX. CONCLUSION

People should be well behaved and well educated to know the value of the management of solid waste and segregation of the generated source. At the segregation point, waste should be used as a source of a different purpose like bio-degradable recycling components and non-biodegradable products provide employment to the rag pickers. In India, induce MSW does not give permission to leachate in the landfill. We have to protect the ground water from the leachate perculation from open dump or land filling process. We should know the importance of the method which is useful for us and hence waste gets stabilized and transfer to the dumping site for the disposal. We generate the effective amount of energy from the waste. Carbon separation ability of composting, more effective resolution of the composting of solid waste goes for incineration and fuel extraction is to be avoided because of MSW use as a fuel need to accept for the effective GHG migration if best treatment is used.Transportation system gives the idea about how perfectly we can collect the waste from the city with low fuel consumption. It effectively collects the waste in time, transfer to the dumping site for the disposal. Public awareness with the concern of the waste management and sanitation in the city is most needed tool.

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