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Smart Solid Waste Management Practice and Scientific Disposal for the Greater Hyderabad City: A Sustainable Approach

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Abstract: Safe handling and scientific disposal of municipal solid waste (MSW) is one of the prime areas of concern for the entire globe. Though the burden of pertinent management is significantly lesser in developed western countries due to the source segregation, but in developing nation, like India, the issue is much more severe due to the rapid increase in the quantity of MSW as a result of urbanization and population growth which is attributed with improper handling and unscientific disposal. The malpractices in the waste management scenario ultimately lead to the all sorts of possible environmental contamination and affect the biotic system. Thus, the idea of a wholesome treatment system with a fullflazed centralized approach provokes the idea of this research work. The present work tried to emphasize a processing and disposal model for MSW, getting generated within the premises of Hyderabad city which often ranges between 5000 to 6000 tones. Initially, the unsegregated and heterogeneous waste has been weighted and introduced to the tipping floor for the loss of excessive moisture and also to reduce the stickiness of the solid mass. Then the pre-sorting and segregation was carried out using 70 mm trammel. Further, the reject of the trammel has been checked for the calorific value (i.e. 3324 cal/g) and other necessary parameters to ensure its' quality to be explored as an alternative fuel. Whereas, the permeate found to contain predominantly organic fraction which was further processed and stabilized using windrow composting method associated to a recovery fraction of 35% to 48%. Ultimately, the process leachate was collected using a gravity flow method and the same has been treated by physicochemical treatment system. The above-delineated process found to be the most appropriate system in terms of handling the bulk quantity of waste and need to be implemented in near future to get rid of the enormous waste mass.

Keywords: Compost, Land Fill, Leachate, Refuse Derived Fuel, Solid Waste

I. Introduction

Solid waste is a broad term, which encompasses all kinds of waste such as Municipal Solid Waste, Industrial Waste, Hazardous Waste, Bio-Medical Waste and Electronic waste depending on their source and composition. Solid wastes are those organic and inorganic waste materials produced by various activities of the society [1]. Solid waste management is becoming a major public health and environmental concern in urban areas of many developing countries. In present-day India is rapidly shifting from agricultural-based nation to industrial and service-oriented country. About 31.2% population is now living in urban areas. Over 377 million urban people are living in 7,935 towns/cities. India is a vast country divided into 29 States and 7 Union Territories (UTs) [2]. The cities having population more than 10 million are basically State capitals, Union Territories, and other business/industrial-oriented centers. India has different geographic and climatic regions (tropical wet, tropical dry, subtropical humid climate, and mountain climate) and four seasons (winter, summer, rainy, and autumn) and accordingly residents living in these zones have different consumption and waste generation pattern. However, till date, no concrete steps had been taken to analyze regional and geographical-specific waste generation patterns for these urban towns and researchers have to rely on the limited data

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available based on the study conducted by Central Pollution Control Board (CPCB), New Delhi; National Engineering and Environmental Research Institute (NEERI), Nagpur; Central Institute of Plastics Engineering and Technology (CIPET), Chennai; and Federation of Indian Chambers of Commerce and Industry [3], New Delhi. Over the last two decades rapid urbanization, change in lifestyles and rise in population has resulted in generation of huge quantities of Municipal Solid Waste (MSW). The quantity of MSW generated is much higher than the quantity collected, transported and disposed, leading to pilling up of uncollected waste in streets, public places and drains [4]. Even the collected waste is mostly dumped on the outskirts of towns/cities and has created serious environmental and public health problems. Studies have shown that a high percentage of individuals who live near or on disposal sites are infected by gastrointestinal parasites, worms, and other pathogenic organisms. The insanitary methods adopted for disposal of municipal solid wastes are, therefore, a serious health concern. The poorly maintained landfill sites are causes of surface and groundwater contamination, and air pollution. Plastic waste has emerged as one of the biggest challenges in municipal solid waste, leading to an acute problem of choking of rivers and drains, ruining the landscape and killing of cattle. Adding to this, the inert material coming from street cleaning, drain cleaning, construction, demolition and renovation are being mixed with the normal waste, aggravating the problems [5]. Hyderabad is the capital and largest city of Telangana state. It occupies 650 kilometres on banks of Musi River. As of 2011, the population of the city was 6.8 million while the metropolitan area had a population of 7.75 million, making it India’s fourth most populous city. Generation of municipal solid waste is also more in high income areas. The waste generated in Hyderabad is 0.6kg/capita/day. The total waste produced in Hyderabad city per day is 3000 ton and per year 10950000 tons. As per recent estimates, the municipal waste generation in metro cities varies between 0.2-0.6 kg/capita/day [6] and urban MSW generation is estimated to be approximately 0.49kg per capita per day [7]. This is estimated to be two are three times. However vary from city to city and the per capita waste generated in Hyderabad 0.62kg/day. But, still the Municipal solid waste management system in Hyderabad comprises only four activities like waste generation, collection, transportation, and disposal [8, 9].

The primary objective of this study was to develop a holistic treatment system capable of addressing the highest amount of heterogeneity with minimal environmental interference and at the same time optimize the recovery of the waste-derived value added co-products.

II. Materials and Method

The management of solid waste begins from individual household and ultimately concludes with landfilling of the unrecyclable and irrecoverable products. The several intermediate processes of scientific waste management are delineated as follows.

A. Pre-sorting

Upon reception of the solid waste, it has been introduced to the tipping floor where it was kept under sunbath over a period of 48h to reduce the stickiness of the waste and minimize the hazard associated with trammel. A mesh size of 70 mm was adopted for initial segregation based on the field practice. The permeate of the trammel was considered as the organic fraction meant for biological stabilizing operation whereas, the reject has been sent for further processing and preparation of refuse-derived fuel (RDF).

B. Windrow Composting

The permeate of the trammel has been shaped in rhomboidal form layer by layer and each layer was inoculated using an effective microorganism culture. Ultimately, a heap was formed and the same was given a number of manual turning after every 7 days. A maturation period of 21 to 27 days was allocated for each trail based on the maturity of the fermentation.

C. Screening

Once, the bio-conversion period was over the semi-fermented material (SFM) was furthermore demiosturised by providing a sunbath curing for 4 days and then the cured material was fed into 20 mm permeate size trammel. The Permeate was separated from the reject and the same was sent for further processing whereas, the reject has been discarded in scientific landfilling.

D. RDF Preparation

As per the standard prescribed by American Society for Testing and Materials (ASTM) anything which has a calorific value more than 2,300 cal/g can be used as RDF. Various different grades of RDF were manufactured and supplied to the local slumps where coal was the only source of cooking. The initiative further caused indirect minimization of CO_2 production of the gaseous atmosphere and helped to reduce global warming.

(a) Grade-II RDF

It’s the quality of RDF obtained from 70 mm trammel. It’s often termed as flump material and cured over a period of at least 2 months for obtaining required calorific value. It

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comprises materials such as paper, plastic, garden twigs, textile, rexin, leather, coconut coir, jute bag, cardboard, sanitary napkins etc. It's a mixed consortium and often attributes with the limited calorific value.

(b) Grade-III RDF

The excess fraction of the Grade-II RDF was thereafter manually segregated for heavy inert like stones, glass etc. and the introduced to the shredder. The shredded material of particle size 25 mm was then conveyed under a magnetic separator where ferrous materials were separated from the valuable mass and finally introduced to the de-dusting trammel with a permeate size of 25 mm. The sticky bio-dust was separated in this facility and the final material was conveyed to the air density separator. There light and the heavy fraction were separated based on the weight of the material.

E. Handling of Inert

Materials with higher stiffness index and specific gravity were non-biodegradable in nature and economically not feasible for any further treatment and thus, the same was discarded in scientific landfilling. In order to arrest the bottom percolation the landfill was attributed with HDPE liner and also leachate and gas collection system was installed for regular monitoring. Moreover, the process leachate was sprayed over the cells of the landfill to accelerate the degradation process.

F. Handling of Process Leachate

Generation of leachate was a subordinate headache and needed to be safely treated and discarded. A physic-chemical treatment system was installed to treat the same and bring to the disposable limit. Primarily the leachate was collected in a collection lagoon and there it was allowed to settle over a period of 3 days. Once the settlable solid got separated due its' higher specific gravity the supernatant fluid mass was pumped and poured into a flash mixer tank. Suitable chemical coagulant was added in optimum dosage and chemically settlable particles were separated. Then the control fluid was introduced into the micron filtration system and the bulky dissolved solids were removed from the same. Finally, the semi-polished effluent from the micron filter was introduced in reverse osmosis (RO) system and final polishing was given.

G. Ground Water Recharge

A bore well of 60 mm diameter was excavated and installed at a pre-determined location with proper aquifer connectivity. In order to ensure the optimum connectivity of the groundwater table and the bore well a flashing operation was conducted with a pressure of 2 kg/cm^2. The borewell was installed with UPVC pipe material to minimize the possible contamination. The purified effluent from RO treatment was finally used for the artificial recharge of the groundwater table.

H. Handling of the Secondary Pollutants

After removal of the treated effluent in RO process and the remaining get converted into secondary pollutant with significantly higher concentrated mass. Handling and safe disposal of the same was performed using a solar evaporation pond system, subjected to the seasonal variation. The leftover portion was finally discarded into scientific landfill.

III. Results and Discussion

Each operation yielded some significant end product and the same has been tested to check it's feasibility to be explored as a potential alternative material in place of the existing and conventional market goods. The analytical test reports of the co-products and process efficacies are delineated as follows.

A. Recovery of City Compost

Windrow composting yielded a maximum recovery of 45% often subjected to seasonal variation. Once the maturation period gets established then the end material undergoes a maturity check by starch-iodine test [10]. The results found to be positive in most of the cases and bright golden yellow colour appeared. A sample of compost has been portrayed in Fig. 1.

Fig. 1. City Compost

B. RDF Preparation

Grade-III RDF found to be most pertinent as per the standards prescribed by ASTM. An optimum calorific value of 3425 cal/gm has been recorded in experimental analysis. Several parameters were analysed for the same and the report has been tabulated in Table I.

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TABLE I
RDF ANALYSIS REPORT

Sl No.	Parameter	Unit	Result	Remark
1	Moisture Content @ 105^{0}C	%	20.8	Within Limit
2	Ash Content @ 850^{0}C	%	13.2	Within Limit
3	Volatile matter @ 550^{0}C	%	65.2	Within Limit
4	Net Calorific Value	cal/g	3425	Within Limit
5	Gross Calorific value	cal/g	3324	Within Limit

C. Disposal of Secondary Pollutants

The reject from RO system was directly sent to the solar evaporation pond where an optimum recovery of 10-12% by volume was observed. Evaporation caused a further concentration of the pollutant and in absence of any feasible handling technique, the same was sent for scientific landfilling.

D. Utilization of Treated Effluent

The permeate of RO process obtained in the due course of treatment found to be within the safe limit of disposal as per the standards prescribed by Bureau of Indian Standards [11]. The treated effluent has been further utilized for the development of green belt and also sewage farming. Whereas, the further polished effluent was directly sent for the recharge of groundwater table. The characteristics of the tertiary treated water have been tabulated in Table II.

TABLE III
CHARACTERISTICS OF THE TERTIARY TREATED WATER

Sl. No.	Parameter	Unit	Result	BIS Limit
1	pH	-	7.23	6.5-8.5
2	Total Suspended Solids (TSS)	mg/l	35	<100
3	Total Dissolved Solids	mg/l	335	<500
3	Biochemical Oxygen Demand (BOD_5)	mg/l	23	<30
4	Chemical Oxygen Demand (COD)	mg/l	124	<250

E. Groundwater Recharge

The advanced treated effluent was directly used for the artificial recharge of the groundwater table. A recharge operation was carried out over the period of 1 year and the variation in the water table before and after the recharge operation has been elaborated in Fig. 2. Furthermore, Fig. 3 shows the flashing and installation of the recharge well at the initial phase.

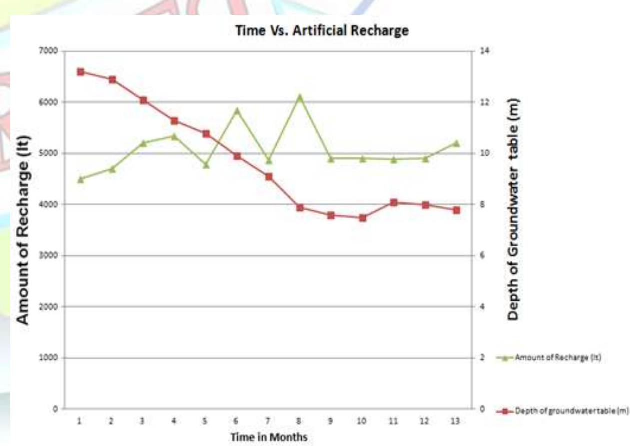

Fig. 2. Analysis report of groundwater recharge

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Fig. 3. Flashing of recharge well during initial installation

IV. CONCLUSION

Due to the enormous growth population in last few decades associated with the scarcity of the available land made the direct landfilling of the MSW almost an impossible phenomenon. Therefore, a full flazed treatment of MSW prior to the disposal is need of the hour and the present study focused to serve the same. The research work tried to emphasize a detailed work plan of the fusion of different physical, chemical, and biological treatment system, which proven to be the most pertinent treatment facility as per the present waste scenario. Additionally, the derivation of the co-products associated with frugal end application also helps to nullify the treatment cost. Thus, the present work successfully empowers the idea of waste being a misplaced resource.

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BIOGRAPHY

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Dr. U. Vijaya Bhaskar Reddy is a former faculty member of Osmania University and has an ample experience of 35 years. He is stalwart in applied environmental geology and holds many prestigious awards in the same field.