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APPROPRIATE SITE SELECTION AND DESIGNING OF ENGINEERED LANDFILL- A CASE STUDY FOR AURANGABAD CITY

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Abstract
Cities with more than 20 lakhs population cater to only 23% of the urban population, the dumpsites in these cities account for almost half (47%) of the total waste present in dumpsites of cities with more than 1 lakh population. These dumpsites are growing in size, becoming an eyesore for these cities, causing considerable social, economic and environmental losses to surroundings. In the here presented case study the identification and designing of engineered land fill sites at Aurangabad having 139 sq.km. area expanded with an population projection of 1.43 million persons in 2019. All the issues were taken into account covering all the guidelines in compliance with Central Public Health and Environmental Engineering Organisation manual 2016, Solid Waste Management Rules 2016, Swach Bharat Mission and Central Pollution Control Board. The objective is to present an evaluation of environmental and social impacts of the Integrated MSW management project with supporting information on baseline environment to assist AMC/developer to take an informed view on environmental and social sensitivity of the project and the level of required mitigations measures to meet environmental and social norms of the GoI. The criteria have been developed keeping in mind the proximity of many land-use facilities. The report also details the detailed layout plan with cost estimations and environmental monitoring programme that should be put in operation during construction and operation phases of the project to provide a timely feedback on the adequacy of recommended mitigation measures.

Keywords- Landfill Sites; waste generation; municipal solid waste management; population forecasting; site sensitivity; sanitary landfill.

1. Introduction

One-third of population of India lives in urban India and produces 54.75 MT of MSW every year. The most prevalent method of disposal of this waste has been open dumping, for most of India's history. The accelerated growth of urban population and increasing economic activities rule out the viability of this method any longer. Swachh Bharat Mission since 2014 has introduced several scientific methods in MSWM (MoHUA, GoI 2020). Environmental adjudication has also mandated the scientific remediation of dumpsites. The fact that many old dumpsites and landfills in the country poses impacts to environment and health of public necessitates actions for remediating dumpsites as well as reclaim the land being degraded.

S. No.	Population Class of Cities	Total Legacy Waste at Dumpsite (in Ton)	20% of Enriched Soil	Volume of enriched soil to landfill assuming density as 0.850 tons /cum
1	>20 Lakh	6,67,17,223	13343445	15698170
2	10-20 Lakhs	1,88,89,538	3777908	4444597
3	5-10 Lakhs	2,20,80,203	4416041	5195342

4	3-5 Lakhs	1,03,38,668	2067734	2432628
5	1-3 Lakhs	2,40,83,948	4816790	5666811
Grand Total		**14,21,09,581**	**28421917**	**33437548**

Table 1. Breakup of Legacy Waste Dumpsites

World today faces many complex environmental problems that pose a constant threat and pressure on an already degraded environment. Rapid urbanization, industrialization, and rapid economic growth lead to excessive exploitation of emerging natural resources (Thomas 1998). The current tendency of industrialization has a huge impact on the natural and man-made environment. The sources of pollution increase with the development of cities and causes pollution of air, water and soil (Ghasemian et, al. 2012**)**. Industrial air pollution accounts for about 2% of lung and heart diseases per year globally. We are caught today in the circle of development impacting adversely the environment (WHO 2001). The efficient and intelligent management of the environment is thus becoming the key to making development sustainable. The limit of urbanization and population growth are increasing, issue for management of waste is increasing too.

This issue is further compounded by the fact that these cities have grown the most in terms of area, and so these dumpsites, which were at one point located in the outskirts of the cities, are now standing tall in the middle, exposing a large number of people to the health hazard of open dumpsites (CPHEEO 2020). Moreover, ULBs stand to gain access to valuable land by remediation of their dumpsites. The 106 dumpsites in the ULBs with a population of more than 5 lakhs must be considered a priority as they affect almost a half (46%) the total urban population. These are also on the verge of overflowing, and their remediation must be prioritized (MoHUA, GoI 2020).

2. Literature Survey

- ***2.1. Engineered Landfill and Site Selection***

Sites on which waste is quarantined by atmosphere till safe known as Engineered landfill also called as Engineered landfill meant its scientifically designed. In other words, a Landfill using geo-synthetic clay liner for segregating refuses from atmosphere until it's safe is called Engineered landfill. The site selection has been done with compliance with attributes and calculation of Site Sensitivity Index **(Rana et. al. 2015).**

- ***2.2. Recent studies in waste segregation system***

These studies and models mainly focus on improving the framework for identifying most suitable location for Landfill sites.

Chang et al. (2008) utilized Fuzzy technique to distinguish reasonable site for landfill in the Lower Rio Grande Valley locale of Texas. The underlying screening measure for taking out unacceptable land was completed utilizing ArcGIS® programming. "Fluffy multi-standards choice examination was chosen to distinguish most appropriate landfill site. The administrators utilized in fluffy enrollment work were "Expansion" and "Augmentation" administrators. Affectability investigation is needed to check the likelihood of changes in ultimate choice. Delgado et al. (2008) looked at three spatial choice help models – Boolean rationale, Binary proof and Overlapping record of various class maps. The requirements presented in the investigation were chosen to agree administrative guidelines concerning landfill site determination methodology. The investigation shows that Boolean rationale is not so much unpredictable but rather more prohibitive strategy than the other two techniques. Double proof and covering list technique requires task of loads to the variables considered in the examination. The appropriateness score is near 0 when the property is ineffectively reasonable in Boolean rationale model. Reasonableness examination is needed for Binary proof and covering file strategy. Tamara et al. (2011) completed Analytical Hierarchy Process assessment utilizing ArcGIS and ArcGIS augmentation ext_ahp.dll for finding appropriate landfill site for garbage removal in Srem district of Republic of Serbia. Master's positioning were utilized and pair-wise examination of seventeen components were finished utilizing AHP. The last reasonableness map was determined by performing overlay investigation in ArcGIS. The centrality of this examination is that two stage rejection measure was performed. At starting stage, limitation maps were readied applying cradle according to ecological enactment and toward the end, indeed the prohibition step was done to check any conceivable blunder in characterizing confined zone. Guide CALCULATOR in ArcGIS was utilized to incorporate the Boolean guides and AHP maps. WEIGHT module in IDRISI was utilized to figure loads and consistency proportions. The last appropriate site was recognized by overlaying the outcomes from singular strategies - Boolean rationale, Analytical Hierarchy Process and Weighted Linear Combination. The outcomes indicated that AHP and WLC strategy would be wise to dynamic forces when contrasted with Boolean rationale (Shahabi et al. 2013). The Consistency Ratio esteem got was 0.02 (< 0.1) (Gorsevski et al.

2012) coordinated different MCDA strategies for distinguishing proof of landfill site in Polog Region of Republic of Macedonia. The focal point of the investigation was to show the weighting adaptability of Ordered weighted normal (OWA) strategy. OWA thinks about two arrangement of loads. The initially set of loads utilizes AHP to allocate loads and relative significance to the models viable. Effat et al. (2012) utilized Weighted Linear Combination technique to plan potential landfill locales for garbage removal for Sinai Peninsula area. Factor loads were determined by two distinct techniques - for Environmental models, AHP was utilized and for financial rules, straight position whole strategy was utilized. Boolean Overlay accessible in ArcGIS programming was utilized to plan requirement maps. Boško Josimović and Igor Marić (2012), the paper accentuations the way that the decision of avoidance models is adapted by a particular actual properties of room. After the period of end of ''negative'' territories, a multi criteria examination of locales that have been designated dependent on a bunch of essential models has been done.

Azadeh Jamshidiet et al. (2013), the ill-advised assortment and removal of waste can cause difficult issues soon. Sadly, in non-industrial nations this issue has not been enough tended to. Additionally, there are likewise some garbage removal downsides in urban communities. This investigation is a GIS approach meant to play out a precise landfill site determination concentrate by presenting a choice emotionally supportive network for maintainable family unit squander the board utilizing a worth centered multi-measures strategy. For this reason, Sarab County was chosen as a contextual analysis. The exploration shows how successful the multi-rules technique is in dealing with wide scopes of measures engaged with site choice examinations. Nur Azriati Mat and Aida **Mauziah Benjamin et al. (2016),** this paper proposes a structure of landfill site choice with a thought of asset prerequisite. This system is created by utilizing the reconciliation of GIS and MCDA to recognize a suitable area for landfill siting. A rundown of choice measures acquired from the writing considered in choosing the best landfill site is additionally introduced. The aftereffects of this investigation could later be utilized to help the waste supervisory crew in building up a productive strong waste administration system. José Luis Solano Peláez, et al. (2020), the commitment of this examination is foreseen to turn out to be more significant as the SLF Pichacay, situated in Azuay area, is required to work just until 2031. Monetary models dependent on a round economy are not a reality in the investigation zone. Under these premises, just 23.83% of Azuay territory is non-prohibitive for the development of a SLF; the majority of the best domains are situated in Nabón, Oña, Santa Isabel, Cuenca, and Sigsig, with LSI esteems above half.

Samadder et al. (2017), once the best earth sound landfill site is found, the following test is to get the public acknowledgment of the proposed site. An itemized investigation of a public acknowledgment investigation of proposed landfill locales is additionally depicted in this paper. The acknowledgment level relies on their insight, experience of visiting the SWM office and the measure of data that is revealed to them. Muhammad Z. Siddiqui et al. (2018), the strategy utilizes a scientific climate gave by geographic data frameworks (GIS) and a dynamic technique gave by the logical chain of command measure (AHP). The GIS is utilized to control and present spatial information. The AHP is utilized to rank potential landfill territories dependent on a wide assortment of standards. Spatial-AHP is shown by applying it to a landfill site determination concentrate in Cleveland County, Oklahoma. The paper additionally investigates the impacts of differing the general significance of different siting measures, landfill size, and area limitation seriousness.

Historically, landfills have been the prevailing option for a definitive removal of city strong waste (**Omar Al-Jarrah et al. 2006).** This paper tends to the issue of siting another landfill utilizing a shrewd framework dependent on fluffy deduction. The proposed framework can oblige new data on the landfill site determination by refreshing its information base. A few components are considered in the siting cycle including geography and topography, normal assets, socio-social angles, and economy and wellbeing The outcomes from testing the framework utilizing various destinations show the adequacy of the framework in the determination cycle. G. Cortésd et al. (2014), the cycle incorporates the task of qualities to every single one of the nonexclusive standards, just as the appraisal of their significance levels. Three distinct regions of Guadalajara, Jalisco, and Mexico DF have been assessed for the contextual analysis, and the methodological proposition has been used to decide the most ideal choice.

From above writing audit it very well may be inferred that GIS and MCDA techniques can possibly recognize reasonable landfill site for a particular area. It expands the precision of the system. The affectability investigation done (Trupti I. Lokhande et al. 2017). Manoj govind karat, et al. (2019), this paper has made an endeavor to distinguish, assess the landfill site determination standards, organize them and inspect the relationship among these models and how much they influence or are influenced by each other, utilizing a coordinated fluffy Delphi-fluffy AHP-The formed approach successfully considers the unsure, abstract and phonetic information from well-qualified feelings, giving more sensible and exact outcomes. Our proposed system effectively evaluates these kinds of data. The removal office siting issue in waste administration has been concentrated by numerous specialists worldwide utilizing MCDM strategies alone or in blend with different methods. The models for critical thinking have developed from the single-basis, maximin models (boosting the normal or least distance between the source and the site) to multi-standards models which incorporate clashing rules (Hale and Moberg et al. 2003). Erkut and Neuman (1989) characterized the issues of unwanted office siting as indicated by: number of offices to be found, arrangement space (organization, tree or general), achievable locale (discrete, consistent, other), distance measure, distance requirements, loads, distance terms included (least distance to the arrangement set or amount of the distances to the arrangement set), communications considered and objective (single target or multi-objective). Also, models have been generally utilized for finding waste landfill destinations to limit openness to people in general and delicate environment (Stowers and Palekar 1993; Yildirim Gbanie et al. 2013).

Erkut and Moran et al. (1991) built up an insightful progressive system measure (AHP) based choice displaying strategy that can be utilized to find disagreeable offices, for example, garbage removal destinations. Frantzis et al. (1993) built up a model utilizing cost and natural rules for landfill site choice. Muttiah et al. (1996) considered, the models of danger to people and climate in determination of ideal landfill site utilizing GIS and reproduced tempering. Baban and Flannagan et al. (1998) examined the significance of two significant challenges for landfill choice: (1) public acknowledgment, which is driven by social and political contemplations and financial motivating forces, and (2) designing and specialized conventions for arranging and security of the actual climate.

Chang and Wei et al. (2000) displayed the utilization of ideal highlights that ought to be considered in the strong waste assortment organization and landfill area, utilizing fluffy multi-target nonlinear whole number programming. Mahler and de Lima (2003) proposed a worth investigation and fluffy rationale based system for the determination of reasonable landfill locales by evaluating and positioning a predefined pool of items dependent on natural and monetary rules. Vasiloglou et al. (2004) introduced a dynamic cycle for the possible area of landfill destinations with wide network investment. They proposed a thorough arrangement of standards for the potential locales including social, ecological, and monetary measurements. Chau et al. (2005) thought about just danger standards (e.g., groundwater migrationn, focuses in danger, squander structure) in the choice of new landfill site utilizing master framework based counterfeit neural network. Kontos et al. (2005) contemplated four models (social, ecological, specialized, and monetary) and eleven sub-rules for the outline of potential landfill destinations. Eiselt (2006) considered least transportation costs for choosing ideal MSW landfill destinations utilizing blended whole number straight programming (MILP). Simsek et al. (2006) introduced a technique considering ground water risk. i.e., the weakness of ground water to tainting. The investigation included the utilization of a DUPIT Model (an adjusted type of DRASTIC Model). Norese et al. (2006) proposed the thought of cost of waste transportation, populace, need of new streets, sway on scene, horticultural worth, and regular natural surroundings security as a portion of the rules in determination of new landfill locales. Queiruga et al. (2008) thought about monetary (land, faculty and energy costs), infrastructural (office access, closeness to occupied zones) and lawful destinations in the choice of landfill site.

4. Study Area

The present chapter gives an elaboration of the study area. Aurangabad City is a 'A' Grade Municipal Corporation located at N 19053'47" E 75023'54" of Maharashtra state. The City is the Capital Tourism of the state. Also, it is the 5th biggest town of Maharashtra. It has an average rain fall of 756.6 mm and maximum and minimum temperature of the city is 42.6 C and 9.1 C respectively.

3. Material and Methods

Collection of research papers, reports, pertaining to SWM for selection of suitable technique is done at the initial stage. A detailed study of city profile to understand status of commercial, residential areas with un expectable changes with waste generation and population were assessed.

A detailed study and procure relevant data of the Study Area and the data for assessment of Landfill has been analysed. Waste generation and inert generation from population forecasting using Microsoft Excel is calculated. Existing Management of MSW and calculation of landfill area has been revived. Evaluation criteria for site selection in compliance with CPCB and SWM Rules 2016 including environmental and socio-economic criteria with availability of land and its suitability has been determined. Design components of Engineered Landfill successfully completed. A layout plan of an Engineered Landfill and Leachate Collection Tank for Aurangabad City using AutoCAD, the layout plan includes detailed estimations, BOQs, and detailed drawings has been prepared. The results i.e., requirement and importance of landfill for the city and how it will cater the inert generated out of MSW processing and that (inert) is disposed in environmentally safe manner has been interpreted.

4. Results and Discussion

4.1. Population Forecasting and Waste Generation of the City

The present population of the city is 1499873 (calculated) and Estimated Population in next 25 years considering the average of Arithmetic Increase Method and Incremental Increase Method will be 2360921 (estimated). Considering per capita waste generation of 437 GPCD, the current waste generation of Aurangabad City is 654.84 TPD. Based on the projected population, waste generation in next 25 years will be 1421.27 TPD considering a increase of 5 GPCD per year. Permissible Quantity of Inert for Landfill considering 15 % will be 213.19 Ton in next 25 years.

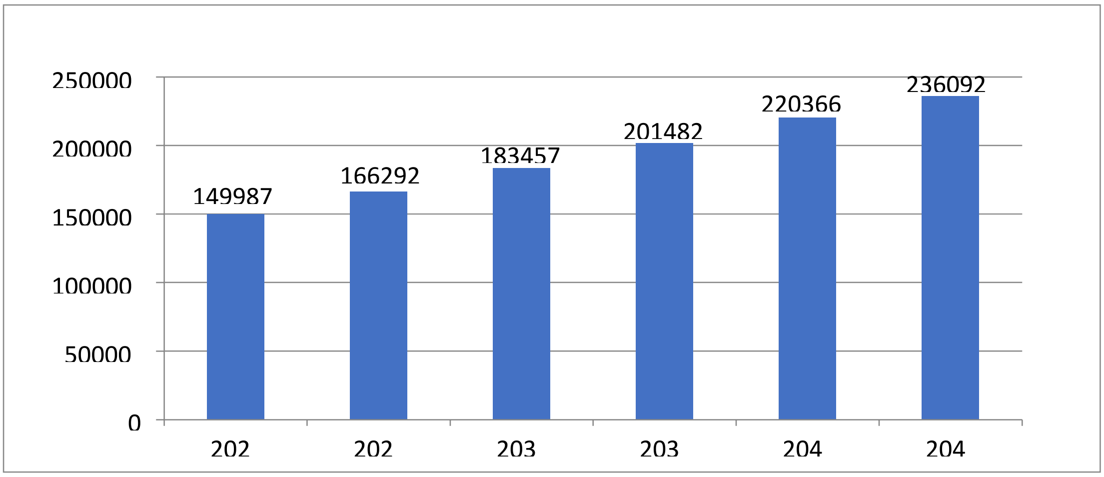

Figure 1. Graph of population projection based on mean of Arithmetic and incremental increase method.

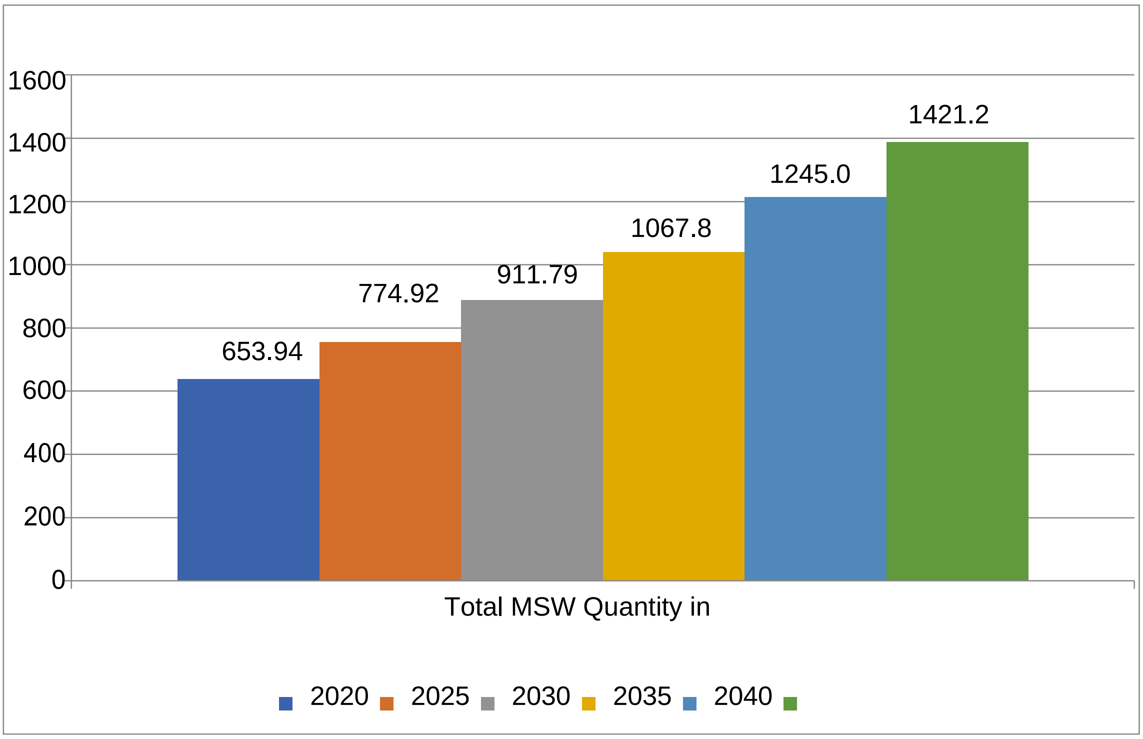

Figure 2. Graph of Waste projection estimation

- ***4.2. Appropriate Site Selection***

Two sites were selected and studied in detail. One appropriate site out of two sites with buffer zone has been identified (i.e: Naregaon Dumping Yard) for engineered landfill facility to facilitate the Municipal Solid Waste in compliance with MSW Rule 2016 and CPCB Guidelines which can be served as a landfill till 2045. As per sensitivity analysis, evaluation score of site for Naregaon is 453.25 which is more than Shekapur i.e. 294.75 as per site sensitivity index for land filling (Rana et. al. 2015).

S. No.	Name of Site	Grand Total Score (Out of 1000)
1.	Shekapur	294.75
2.	Naregaon	453.25

Table 2. Site Evaluation Score.

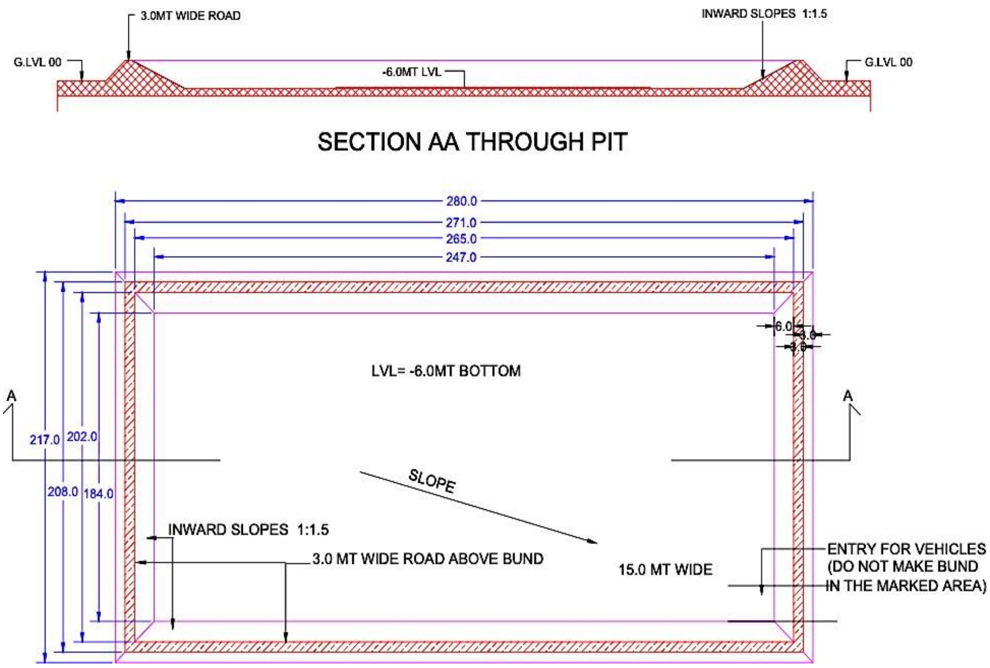

Figure 3. Detailed Drawing of Key Plan for Engineered Landfill. **Notes:** All dimensions in meter.

- ***4.3 Conceptual Design of Engineered Landfill***

Keeping in mind the availability of land and capital cost, the construction scientific landfill is divided in two phases of same dimensions proposed for keeping the waste in next 10 years each at the initial stage. The total volume of inert/ non- bio degradable rejects from processing Plant (assuming 15% maximum of feed) for disposal to landfill, assuming density as 0.850 tons per cubic meter for the duration 2020–2029 is 492476 cubic-meter. Considering 30% volume of soil cover, linear and bund and 12-meter height of the landfill. Therefore, in the first year, design for the Engineered landfill is done for first 10 years for the square metre of 53530. Hence the size of the Engineered landfill is 265-meter x 202-meter.

DESIGN FOR SANITARY LANDFILL			
Waste Volume required for landfill for ten years (2020-2029)	Cum	=	492476
Volume of Soil cover, Linear and Bund	30%	=	147742.8
Total Landfill Volume	cum	=	640218.8
Height of the Landfill	m	=	12
Area of Landfill	Sq m	=	53351.5

Table 3. Sanitary Landfill for Process Rejects Section Details

- ***4.4. Leachate Evaluation***

Considering 756.6 millimetre per year average total precipitation in the City and 80% rainfall in four months, the leachate quantity is 269.79 cubic meter per day. Rainy season for continuous 3 days with no evaporation due to sunlight is assumed. Therefore, the area required for leachate tank which can hold the quantity of leachate for 3 days is 809.37 cubic meter. 3.0-meter depth of leachate tank and 30-centimetre free board is provided. Hence size of leachate tank is 20 x 14 x 3.3 cubic meter.

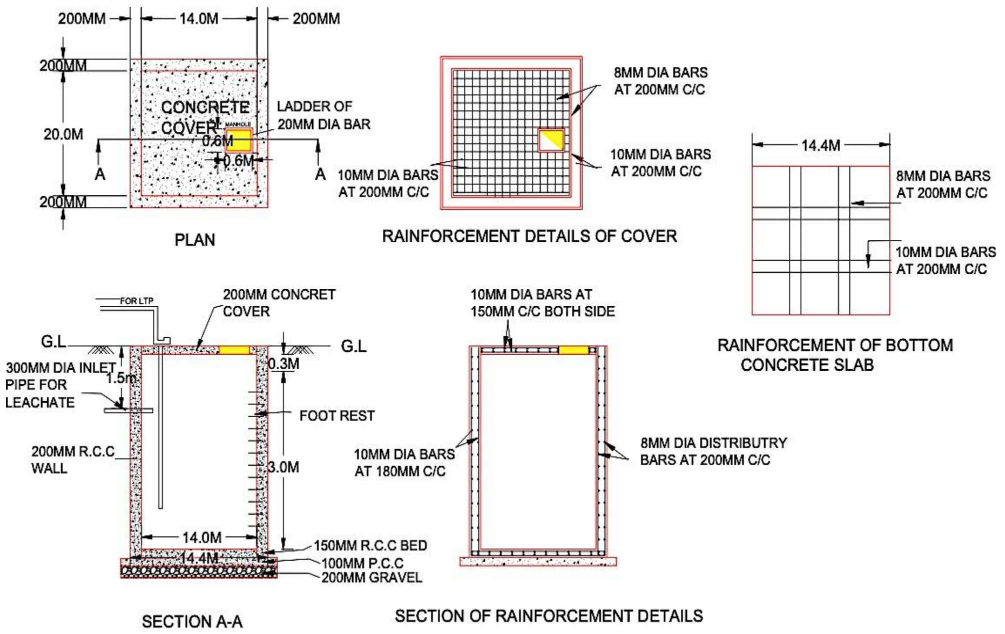

Figure 4. Detailed Layout Plan of Leachate Collection Tank. Notes: All dimensions in meter.

- ***4.5. Detailed Cost Estimation***

Detailed cost estimate with reference of Sate Schedule of Rates for Engineered landfill and leachate collection tank is done. It is estimated that, the cost of proposed Engineered Landfill of 162-meter x 105 meter is 7.92 Crore Rupee. and the cost of proposed Leachate collection tank is 14.96 lakh Rupee inclusive of Goods and Services Tax.

5. Conclusions

The cities will soon have to deal with the fact that these dumpsites will soon be unable to take in any more waste, and it is imperative that they are proactive in tackling this issue.

The study of existing Solid Waste Management system of Aurangabad Municipal Corporation has been carried out based on Aurangabad Corporation records. According to cost estimation and literature review, it is found that the engineered scientific landfill is best suitable for MSW in ULBs like Aurangabad because indiscriminate disposal of waste and unscientific design of these landfills has resulted in severe environmental and health hazards for the urban population of India's major cities. It is concluded that Aurangabad City generates non-recyclable material (i.e., inert, silt, sweeping waste) from Municipal Solid Waste estimated for next 25 years, needed to be handled by Aurangabad City Municipal Corporation (AMC), which required Engineered Landfill Facility for compliance of MSW Rule 2016. Considering the same, a methodology has been developed which has enabled to select appropriate Landfill sites considering SWM Rules 2016 and CPCB Guidelines. It is observed that, SWM handling rules 2016 is not fully complying at Aurangabad. Presently the city about 250 TPD is being processed while the present production of MSW is 655 TPD. Recently the expansion of city causing increase in population has posed solid waste management issues severely. Considering the Service Level Benchmark, at source segregating, collecting as well as transporting of MSWM at Aurangabad city is 60%. Proposed design of landfill fulfils this need on the criteria of population, available land, volume of waste generated, weather conditions, environmental factors and future scope.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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