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Environmental Aspects of Sanitary Landfill Site Selection and Design for Municipal Solid Waste of Kandahar City, Afghanistan

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Abstract: *Concerns about global, regional and local emission of pollutants are at the alarm level especially in term of MSW. Increasing standard of living along with rapid urbanization and the limited capacity of the existing MSWMS make Afghanistan's major cities, for example, Kandahar City to tackle with the problem of MSW management and hence it is needed to make attempts to shift from primitive MSWMSs toward IWMSs. The first objective of this study was to find out the composition of MSW at disposal site and at houses and shops to know the composition at early disposal and at landfills and amount of recyclable materials during these two stages. It was shown that composition of MSW is affected mostly by construction materials and it has no yard waste and less food waste at disposal site but at the houses and shops the food waste almost made 70% of the composition that is because of Kandahar hot and dry climate and that MSW takes 3-7 days to be disposed at landfill from houses. Moreover, it doesn't produce much leachate and is simply evaporated in the open space. The second objective which was to select a site for sanitary landfill was obtained by studying and analyzing several potential areas around Kandahar City. Among the areas many factors of the (area near to Kandahar Air Field) were comparable with the standards for a sanitary landfill and hence the research suggested this area first. The third objective of the study was to design a sanitary landfill based on the composition of MSW obtained in the first objective and site selected for the sanitary landfill. The design was done for a 20 year period for the population of Kandahar City. As the soil and water table of the selected site was preferable, the design had not any special case and therefore components of a simple and basic sanitary landfill were calculated for its design.*

Keywords–*Integrated Waste Management System, Kandahar City, Landfill Design, MSW Composition, Sanitary Landfill*

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I. Introduction

Population of the world has increased to more than 7 billion in 2013 [1]. Higher population consumes more resources and energy; hence, producing more refuses which in turn pollute the Earth beyond its assimilation capacity. In other words, the extraction from the biogeochemical cycling processes such as C, N, P and S cycles is at higher rate than they are supposed to be put back into their cycles [2]. Therefore, the management of MSW has developed from simple dumping to waste-to-energy schemes or integrated methods of management which are considered sustainable [3].

Environmental pollution problem is more evident in poor and developing countries compared to developed countries because low-income countries have inadequate improved technologies and management to handle the environmental problems [4]. Afghanistan, a post conflict and growing nation in South Asia, lacks infrastructures, technology and management to cope over environmental problems especially in its major cities, for example, Kandahar City.

Kandahar city is the capital of Kandahar province, and the former capital and second largest city in Afghanistan. Kandahar city is situated in the southeastern area of Afghanistan at approximately 1005 meters above sea level. In recent years, the city has experienced population fluctuation due to influxes of displaced persons and refugees caused by war and drought.

Kandahar City, as with most urban conurbations within Afghanistan, is facing many challenges in the Municipal Solid Waste (MSW) management sector. Urban population expansion, economic growth coupled with increased waste production, dilapidated waste handling equipment due to lack of investment, and limited financial, institutional, human, and infrastructural resources result in an ineffective municipal waste management system with associated adverse environment, health and safety impacts. Waste collection coverage throughout Kandahar is severely limited and ineffective. There are no sanitary or environmentally controlled waste disposal or treatment facilities and waste is deposited in an open dump site which is largely undefined, uncontrolled, unregulated and unmanaged with no environmental control [5]. Moreover, UNEP reports that

Afghanistan has no proper sanitary landfills, and is currently relying on unmanaged dumpsites of waste storage [6]. These dumpsites are often situated in proximity to major communities, which poses threat to humans' health and water resources. Currently Kandahar City faces issues related to MSW such as, drainages clogged due to uncontrolled wastes leading to stagnant waters and hence mosquitos breeding, in addition, causes flood during rain fall. Volatile organic compounds and dioxins in air-emissions are increasing cancer incidence. Contaminated leachate and surface run-off from land disposal facilities are affecting down gradient ground and surface water quality.

A research study need to be conducted to find out the physical composition of the MSW, site selection for sanitary landfill and carryout the design for sanitary landfill for the MSW of Kandahar City, Afghanistan which will help decreasing health and environmental issues and will add to the economy development of Kandahar City.This is a fresh research, since site selection and design for a sanitary landfill is not carried out for Kandahar City. Hence, for Kandahar City, with an area of about 250 km^2 [7] and population of 850000 [8] a sanitary landfill is necessary.

Open dump landfilling is not a sustainable MSWM system [9] which is presently adopted as MSW disposing system for Kandahar City. It can cause several health related diseases and environmental pollution through the emission of greenhouse gases to the air, leaching to the underground water and decreasing the safety degree of the soil.

A sanitary landfill with higher design capacity for Kandahar City will not only dispose the MSW management in a safe manner, but also will decrease the amount of disposal MSW and have development and economic aspects (biogas, compost, land saving) directly or indirectly for government and people.

II. Literature Review

When materials at the stage of original source bear no value after they are used, they become waste to be thrown away or discarded [10].The generation of MSW varies from region to region based on the income level of a family and society, geographical setting, season of the year, the extension of salvaging and recycling, public attitude, characteristics of services and regulation [11]. According to [12], the MSW in southern Afghanistan cities is roughly one third organic, one third soil, floor sweeping, ash and other fine particles and the remaining one third is being mixed consumable of which is collected by scavengers in the community.

According to [13], integrated waste management is, "The integration of waste streams, collection and treatment methods, environmental benefit, economic optimization and societal acceptability into a practical system for any region." According to [14], a particular waste management approach is not suitable for handling all waste streams in all areas and circumstances. It is essential that integrated systems of waste management be considered within the path towards achieving sustainable development. Thus, waste management hierarchy is a guideline accepted internationally for waste management [15]. The hierarchy insists on decreasing, reclaiming, and recycling most of wastes.The concept behind the resource recovery system in MSW disposal is to view the disposal of MSW as an opportunity as well as a problem because this major environmental, social and economic problem can be converted into a valuable resource for society.

As sanitary landfilling is an inevitable part of MSW (municipal solid waste) management system [16], appropriate site selection of landfills may play a key role in reducing the environment contamination. Landfill siting is a difficult, complex, tedious, and protracted process requiring evaluation of many different criteria [17] since it has to combine social, environmental, technical, and financial factors.

Economic factors must be considered in the siting of land- fills, which include the costs associated with the acquisition, development, and operation of the site [18][19][20] (Delgado et al. 2008; Erkut and Moran 1991; Kontos et al. 2003).

The following steps should be followed while selecting the land:

- Setting up of a location criteria
- Identification of search area
- Drawing up list of potential sites
- Data Collection
- Selection of few best-ranked sites
- Environmental impact assessment
- Final site selection and land acquisition

According to [21] (Tagaris. At al. 2003) while selecting the area, surface water, infrastructure, local flora and fauna, distance from urban area, ground water table, airports, public roads, and industrial development, unstable zone, distance from environmentally sensitive or protected areasshould be considered.

After studying different restricted lists, we identify the standard places which are potentially developed. In addition, the area where there is little land, old or contaminated areas of wastes need special deigns. Therefore, we should determine the capacity and durability of the land first to select the sanitary landfills [22] (EPA, 2007).

Information about landfills can be obtained fromtopography; soil, transportation and other essential maps [22] (EPA, 2007). In environmental impact assessment risk of flooding, subsidence and landslide, geological and hydrogeological conditions and assessment of public reaction should be considered.

In the design phase of a landfill the areas where liquid is not absorbed to land and do not harm groundwater, single lined landfills are convenient, otherwise, double or multi lined landfills are recommended.In a Single-lined landfill only clay is compacted in the bed of the landfill, where in double or multiple lined landfills in addition to the clay, it contains High Density Polyethylene (HDPE) to prevent absorption [22] (EPA, 2007).

Designing the sanitary landfill is for the following needs to be addressed:

- Provide buffer zones and operational controls to handle noise, odor and dust.
- Provide for safe and efficient unloading of collection and/or transfer vehicles at the working face.
- Provide collection, treatment, and discharge systems for all leachate contaminated waters
- Provide collection, ventilation, and, as needed, flaring systems for all landfill gases to meet environmental, health and safety needs of the workers and surrounding residential community.
- Provide fencing and gate control facilities, including weighbridges.

Field Studies for Designing Sanitary Landfill

- Conduct surveys and collect samples for analysis, as needed, to confirm the quantity and density of solid wastes for which the sanitary landfill will be designed.
- Conduct topographic survey, if not already done as part of previous field investigations.
- Conduct test holes to assess the soil conditions and types of earth's layers and assess the seasonal high ground water levels.
- Conduct biological field studies to assess whether there are significant species or habitat at the site and identify agricultural activities. Delineate any on-site wetlands by soils and plant species.
- Gather information from available sources and interviews regarding the socio-economic and cultural background of the resident population surrounding the site.
- Determine wind, rainfall, evaporation and other conditions which will affect the movement of windblown litter, dust, odor, and landfill gases.

Some important standards for sanitary landfill design are as followings:

- Daily cover that prevents the odor and spread of solid waste
- Compaction of solid waste to decrease the volume [23] (Mortaja,1998)
- Study of water in the upper and bottom part of landfill
- Collection of liquid produced from solid waste hence absorbed to land [24] (Kavanagh,1984)
- Polyethylene cover to be laid on compacted clay to prevent liquid absorption [25] (Hughes et al ,2008)

Base Sealing System

Base of landfill needs to be sealed appropriately by layers such as mineral sealing layer clay, high density poly ethylene layer, geo-textile protection layer and drainage layer.

Mineral sealing layer clay has to be in four layers each 225 mm and composed of 10% clay, 5% organic matter and 15% carbonate. It should conform to permeability capacity of is $kf \leq 1x\ 9^{-10}$m/s and proctor density (DPR) of DPR ≥ 95% [26] (Hans-Gunter Ramke, 2001). Next, high density poly ethylene layer should cover the mineral layer with a thickness not less than 2 mm and we need to make sure that there is no water under this layer [26] (Hans-Günter Ramke, 2001). Third, geo-textile protection layer has to be applied to protect HDPE layer. This layer has conformed weight of more than 1200 g/m2, and be tolerable against compression and tension forces and resistant against slippery [27] (DFBOT, 2001). Lastly, drainage layer is applied over the geo-textile layer. The liquid which pass through this layer enter into collection pipes fixed in the layer. This layer should consist of ingredient size of 16mm-32mm with a thickness of morethan 30 cm and permeability capacity of $kf \leq 1 * 10^{-3}$ m/s [28] [27] (MSW Rules,2000 and DFBOT, 2001).

Surface Sealing System

In addition to the layers applied in the bottom part of the landfill, there are layers located in the top part of the landfill such as compensation layer, mineral sealing layer clay, drainage layer and final cover.

Compensation layer is applied when MSW is compacted in landfills. This layer is made of similar and non-binding materials with a thickness reaches up to 300mm [27] (DFBOT, 2001). Second, mineral sealing layer clay is applied over the compensation layer with a thickness of 600mm applied in two stages [27] (DFBOT, 2001). Third, drainage layer with ingredients size of more than 16-32mm and thickness of 150 mm is used to drain the absorbed water from topsoil or last layer [27] (DFBOT, 2001). Lastly, final cover, whose thickness reaches to 400mm, is applied to prevent the erosion caused by wind or water, water leakage and gas spread; and provideopportunity for the plants growth, and aesthetic of the site

Treatment of Leachate

Most of the studies show that when the liquid from the solid wastes mix to the water, it harms the plants inside the water andaffects water quality. Hence, it is needed to be treated by methods such as biological treatment (aerobic and anaerobic biological stability), physical treatment, chemical treatment (precipitation, surface absorption, chemical oxidization) [29] (Kavazanjian, 2001).The factors effecting liquid formation are the type of materials from which the solid wastes are formed, pH, temperature, humidity/moisture, time, weather, the characteristics of the rain entering into landfill and structure of final cover [30] (Craw ford and smith, 1985).

Landfill Gases

The gas produced from the solid wastes need to be studied properly. The characteristics of gases depend on the type of solid wastes and the liquid, which changes according to time. Most of the gases are produced during the degradation by bacteria; the bacteria degrade organic solid waste, and thus produce gases such as,CH_4, CO_2, H_2S, CO, O_2, N_2, H_2 and other gases. The gases produced from landfills are used for electricity or for cooking [31] (Jaber &Nassar, 2007)

Table 1 Approximate Structure of gases in Landfill

Gas	% Concentration Range	
	Lower limit	Upper limit
Methane	40	70
Carbon dioxide	30	60
Carbon monoxide	0	3
Oxygen	0	5
Nitrogen	0	3
Hydrogen	0	5
Hydrogen sulfide	0	2
Trace Gases	0	1

Source: [31]

III. Methodology

This is an applied or adaptive research by use, descriptive research by objective and qualitative and quantitative research by statement. As the research has three objectives, namely, finding out the composition of municipal solid wastes, selecting sanitary landfill area considering the composition of MSW obtained in objective one and the design of the sanitary landfill for MSW of Kandahar City in the selected area.

During data collection questionnaire, field observation surveys and site visits were conducted. Primary data were collected through questionnaire, field observation and site visit whereas secondary data were collected from the documents, reports, journals, maps, government directorate offices and NGOs especially related to the research topic.

After the primary data collection the data were analyzed through Microsoft Excel and Statistical Package for Social Sciences (SPSS) programs. Figure 1 shows the general methodology of the study.

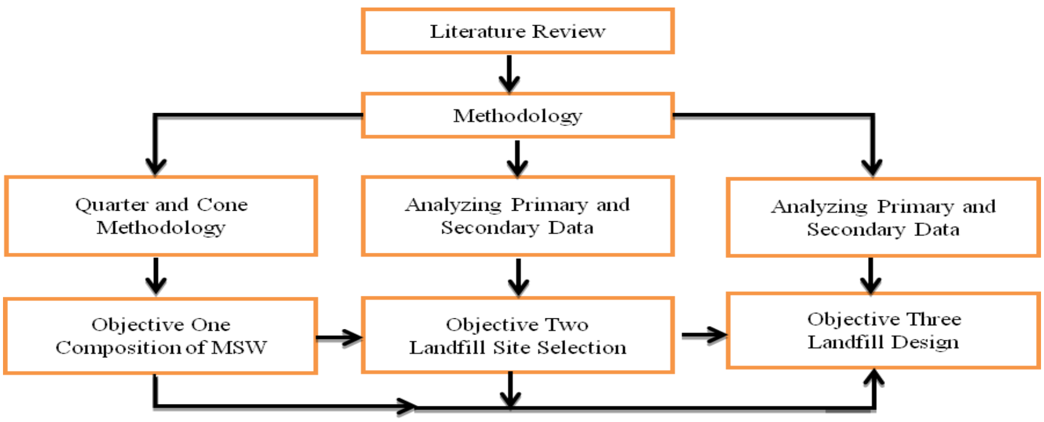

Figure 1: General Methodology of the study

The composition of MSW was achieved by cone and quarter methodology. The City is divided into 15 sub-districts. In each district 3 houses of low, middle and high income were surveyed for 7 consecutive days of a week 2 times (wet and dry seasons) through the year. In addition to the houses, 3 kinds of shops (hotel, grocery and vegetable shops) were surveyed at the same manner as houses were surveyed. Moreover, the composition was surveyed at the disposal site two times throughout the year. For composition of MSW, food waste, plastic, glass, paper, metal, wood/clothes/rubber and inert (stone, brick, dust, sand and etc) were analyzed.

Frequency of sample taken at houses=

houses (3) x days of the week (7) x season of the year (2) x sub districts in Kandahar City (15) = 630eq. (1)

Frequency of sample taken at shops=

shops (3) x days of the week (7) x season of the year (2) x sub districts in Kandahar City (15) = 630eq. (2)

The "cone and quarter" is a sampling method for extracting sub-samples from a large sample material. Although this sampling method is perhaps more time consuming than some other methods (e.g. taking "random" sub-samples from locations in the large pile that appear "normal"), the "cone and quarter" method is the least subjective way of extracting a sub-sample and creates the most accurate results [12].

The second objective which is selection of site for sanitary landfill was carried out by observing multiple sites and choosing the site which can meet the standards for a sanitary landfill the most. It was done throughout the primary and secondary data that we got about the sites and the third objective which is the design of the sanitary landfill was carried out considering the site and the composition of the MSW.

IV. Conclusion

Objective One

Kandahar City is the second largest city of Afghanistan. It is located in southwest zone of the country as the economic center of the zone with a GDP per capita of $ 678. It has dry hot climate and the annual precipitation is 190.6 mm. The city covers an area of 250 km^2. The city population is around 850000 and 32% of the population is educated.

The sources of MSW in Kandahar City are residential areas, commercial areas, institutions, street sweepings, and canals and drainages cleaning. The industrial source is not covered by Kandahar Municipality.

According to the interview with municipality officials, it was reported that average annual generated MSW in the city from the last 5 years record was 264146 ton (458586 m^3). Hence, with 850000 population of the city, the average MSW generation per capita at the disposal site is 0.85 kg/capita/day.

After the wastes are collected from the city, they are disposed of in a controlled open dump area about 15 km away from the city. Previously, the MSW of the city was dumped along the dry river of Turnak River but then, with the assist of USAID a defined and managed transitional waste accumulation site (TWAS) with basic environmental controls (leachate collection system and pond) was established by RAMP UP-South in January, 2013. The design capacity of the new site (TWAS) was about one year and it was filled soon. Then, the wastes were disposed of in Meyan Koh in a controlled landfill but due to insecurity it was left unfilled. Later, the municipality decided to dispose waste back in the dry bed of Turnak River.

The survey was done in two seasons (dry and wet) and each time for 7 consecutive days to better present the composition at houses, shops, hotels and grocery shops, and two times at the disposal sites.

The reduced sample by cone and quarter methodology was sorted out manually to 10 components which were food waste, plastic, paper and cardboard,glass,metal, textile/wood/rubber, miscellaneous (not separable) and inert (stone, brick, dust, sand, etc.). Afterwards, the weight of each component and volume of the whole sample was measured and recorded to know the composition percentage by weight and density of MSW.

Table 2 Kandahar MSW Composition and Density at Turnak Disposal Site

Composition	***Percentage***		
	Wet Season	**Dry Season**	**Average**
Food waste	25.4	24.3	24.8
Plastic	9.4	13.1	11.2
Paper & Cardboard	1.7	2	1.9
Glass	3.4	3.3	3.3
Metal	0.4	0.7	0.6
Textile / Wood /Rubber	1.9	1.9	1.9
Miscellaneous (not separate able)	10.7	12.9	11.8
Inert (stone, brick, dust, sand, etc)	47.1	41.8	44.5
Total Weight (kg)	75	78	77
Total Volume (m^3)	0.129	0.132	0.130
Density (kg/m^3)	581.4	591	592

Table 3 Average MSW Composition and generation in 15 Sub-district of Kandahar City

Composition	*Average MSW Composition (gr)*		*Average MSW Generation (gr)/capita/day*	
	Weight	**%**	**Weight**	**%**
Food Waste	404939.08	70	335.685	69.5
Plastic	27188.7668	4.7	20.769	4.3
Paper	8098.7816	1.4	7.728	1.6
Glass	4049.3908	0.7	3.864	0.8
Metal	9255.7504	1.6	3.864	0.8
Wood/Clothes/Rubber	2892.422	0.5	1.449	0.3
Inert (stone, brick, dust, sand, etc)	122060.2084	21.1	109.641	22.7
Total	578484.4		483	

It can be concluded that Kandahar City has denser MSW mainly because of the construction waste such as bricks, soil and sands. The density is higher than typical density of MSW which is 300 kg/m^3.

Second Objective

The second goal was selecting the sanitary landfill site, in which we discussed what kinds of areas are best suited for landfills, that are environmentally friendly, and all the districts of the city can have access to it. Then there is achieving the third goal which is designing the sanitary landfill to last for several years. It is noteworthy that data about this goal was achieved by visiting and investigating in all the districts of Kandahar City. Moreover, we have collected information from relevant departments and organizations for better accuracy. We studied the four sides of Kandahar City for site selection of sanitary landfill.

Afghanistan is a mountainous although it has land surfaces, deserts, rivers and lakes. Kandahar City is located between two plain rivers, Arghandab and Tarnak. There are mountains and cliffs to its north and Risgistan desert, which lies up to Helmand Province and is one of the largest deserts in South Afghanistan.

Table 4 Topography of Kandahar City.

Land Type	Flat	Mountainous	Semi Mountainous	Semi Flat	Not Reported	Total
Percentage	84.5	2.6	5	6.8	1.1	100

Source:[32] Central statistics office /UNFPA socio Economic and demographic profile

Kandahar Province has hot and dry climate, where it rains little. The average raining rate in Kandahar was 191 mm during 1964-1983, while its average vapor rate, based on 1971-1963 data, is more than 1500 mm each year [33] (CDM, 2003).

The following chart shows us the high and low temperature of Kandahar Province throughout the 12 months of the year, the highest is in July while the lowest degree is in January. The wind direction is always from the north and west to the south and east [34]. (Farve and Kanmal, 2004)

Table 5 High and low temperature of Kandahar Province.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**may**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**year**
Average High °C	12.2	14.8	21.6	28.1	34.1	39.1	40.2	38.2	34.0	27.5	21.0	15.4	27.2
Average Low °C	0.0	2.4	7.1	12.3	15.8	19.5	22.5	20.0	13.5	8.5	3.3	1.0	10.5

Source: [35] HKO.2011

We selected different areas for the landfills first, and then we evaluated the advantages and disadvantages of each area. Finally, we selected the most suitable area for the landfill, and the characteristics of each area are stated below:

Table 6 Summary of the characteristics of the seven sites around Kandahar City studied for the selection of sanitary landfill site

Criteria	Tarnak Area	Bagh-e Pul Area	The Area Located in Daman District	Mian Koh Area	Area near to Amir Lalai Hotel	The Area beside Kandahar Airport	Rigistan Area
Northing	31° 33' 51"	31° 35' 30"	31° 39' 45"	31° 40' 54"	31° 37' 45"	31° 31' 36"	31° 12' 22"
Easting	65° 51' 23"	65° 34' 12"	66° 02' 36"	65° 43' 59"	65° 51' 08"	65° 53' 15"	65° 36' 57"
Altitude	1015m	1006m	1110m	1126m	1035m	1039m	1174m
Nearest Mountain Distance	2.67 km	On hillside	Very far	On hillside	4 km	Very far	No Mountain
Distance to City	10.7 km	15 km	30 km	5.9 km	10 km	20 km	28 km
Nearby Trees	No	Yes	No	No	No	No	No
Nearby Animals	No	No	No	No	No	No	No
Flood Contingency	Yes	No	No	No	Yes	No	No
Water Table Depth	16 m	20-25 m	25 m	25-30 m	25 m	20-25 m	Very Deep
Soil Type	Hard Soil	Not Suitable	Moderate	Rocky	Not Suitable	Suitable	Not Suitable
Nearest Residential Area (village) Distance	1.35 km	0.4 km	4.5 km	0.7 km	0.33 km	4 km	Very Far
Nearest Traffic Road Distance	1 km	0.6 km	1 km	0.2 km	1.2 km	2.5 km	End of Road
Surface Water (rivers) Distance	1 km	0.67 km	Very Far	4 km	2.2km	0.7 km	Very Far
Airports Distance	5.3 km	30 km	24 km	27 km	13 km	2.5 km	30 km
Unstable Zone	Needs Improvement	Good	Excellent	Satisfactory	Fair	Very good	Poor
Flooding over 100 years	Often	Possible	Possible	Possible	Possible	Possible	Possible
Slope	0.5 to 1.2 %	13 to 17 %	0.6 to 1.3 %	6.7 to 13 %	1.1 to 3.2 %	6.2 to 3.2 %	
Slope Direction	East to West	North to South	North to South	East to West	North to South	North to South	North to South
Distance to Industrial Site	2 km	30 km	17 km	1.5 km	1.3 km	11 km	Very Far
Wind speed	Average	Average	Average to High	Low	Average	Average to High	High
Site Capacity (Area)	1.76 Sq. Km	5.6 Sq. Km	3.8 Sq. Km	1.14 Sq. Km	Not Enough	Very High	Not Enough
Buffer zones	Less than 100 m	Less than 300 m	More than 500 m				
Ranking (by this study)	Seventh	Fourth	Second	Third	Fifth	First	Sixth

Third Objective

The site for landfill is chosen to be the Area beside Kandahar Airport and in the composition of MSW there are no any extreme toxic contents. Therefore, the calculation for the design of a basic sanitary landfill is carried out.

The population increase in Kandahar is 2.71% [36] (Agha Mohammad, 2012), and in 2014 the average produced solid waste quantity was 236,520 Tons [37] (Rahmani, 2015). Below formula is used for the determination of solid waste quantity

$Q_i = Q_p(1 + r)^n$ *eq. (3)*

Where,

Q_i = Quantity of Solid waste in coming year; Q_p = Current quantity of Solid waste; r = Populaitonincrease percentage (Growth Rate); n = Number of years [38] (CEPIS/PAHO, 2003).

The quantity of solid waste from 2017 to 2036 is about 6,430,351 tons. If it is compacted normally, the density reaches 445 kg/m^3[37] (Rahmani, 2015). In this research thedensity of compactedMSW is considered 445 kg/m^3 because still adequate machinery for well compaction is not available in Afghanistan.

For landfill about 20% - 25% extra volume need to be considered for daily cover, and 0.5% or more slope for the length; and in small areas the slope need to be 3% or more [26] (Hans, 2001).In this research the cover quantity is considered 20% because most of the solid waste is dry, thus does not require more cover. The volume of a trapezoidal landfill is calculated based on MSW volume, its compaction and the extra volume for covering.

$$v = \frac{m}{p} = \frac{MSW\ volume}{density\ \ of\ compacted\ \ MSW} = \frac{6{,}430{,}351{,}100\ kg}{445\ kg/m3} = 14{,}450{,}227.2\ m^3 \qquad eq.\ (4)$$

The 20% of the volume for covering is 2,890,045.4 m^3 and hence, a total volume of 17,340,272.6 m3 is required. For the length, width and height of the landfill we follow the formula for trapezoidal volume.

$$V = \frac{1}{2}(b_1 + b_2) * h * L \qquad eq\ (5)$$

If we consider the trapezoid sides slope ½, $h = 12\,m$ and $b_1 = b_2 - 48$, we get the $L = 1548\,m$, $b_2 = 987.4\,m$,$b_1 = 943.4\,m$ and the area at the ground level$A = b_2 * L = 987.4 * 1548 = 1528495.2\,m^2$
Solid wastes contains 15% moisture, hence, total MSW of 20 years produces 134 cubic meter. As Kandahar City has less precipitation and landfill is covered so small diameter pipes are required, as per literature review in each 15 m distance one pipe is laid which is made of HDPE materials, the diameter reach to (4-4.5) inch, the length slope is 0.5% and the slope for the liquid entering into pipe is considered 3% accordingly. The diameter of big pipes is 18-20 inch. There are two big pipes which lay in the two sides on the lengthwise, and the small pipes transfer the liquid to big pipes, on the lengthwise of landfill in the middle of 1548 meter half liquid is transferred to one side and half liquid is transferred to the other side, each side shall have 0.5% slope. For the liquid coming from the pipes there shall be wells considered on four corners containing (5*5*3m) volume, every day or once in two days the liquid is pumped from the wells, thus transferred to treatment plants.

As this landfill has engineering structure, after one year gases are produced where methane and carbon dioxide are the major contents respectively [39] (Land GEM, 2005). However,pipes shall be laid in standard position in each 15-20 meter with the diameter of 3-4 inches. According to the decomposition rate equation, Figure 2 shows the quantity of gas produced in 20 years. The maximum gas quantity in landfill is produced in 2036.

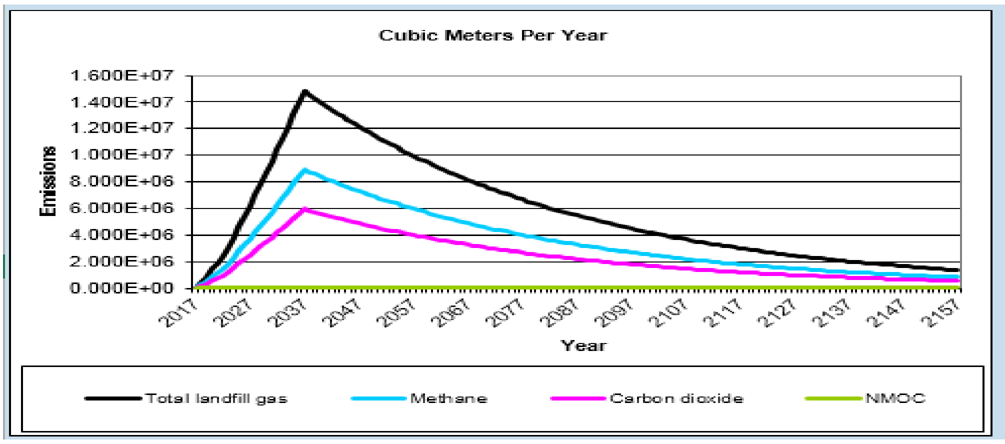

Figure 2 Gases production in sanitary landfill for MSW of 20 years

Before placing the MSW some layers should be place. First, the soil under the solid waste need to be compacted, so that water infiltration is decreased, clay should be placed over the soil with the height of 2-3 foot in three layers and compacted, and in this case the soil infiltration capacity will be Kf≤1x10-9 m/s. Then, an HDPE plastic layer will be laid, which has 0.06-60 mm thickness. Next, a layer to pass the liquid with the particles size of 16-32 mm and height of 30-60 cm should be laid. Finally, solid waste is placed [26] (Hans, 2001).When the solid waste is compacted, thus daily soil cover should be added with the thickness of 15 cm; and when the landfill is filled completely, first, a 30 cm soil cover is to be added. Then, two layers of clay each with a thickness of 30 cm are laid. Next, an HDPE plastic or isogam layer is applied with the thickness of 0.06-60 mm. Afterwards, water passing layer with the thickness of 30 cm; and finally, a soil layer of 60 cm is applied where plants can be grown [26] (Hans, 2001).

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