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A Case Study of Fukuoka Landfill Method and Environmental Impact Assessment of Solid Waste Management in Kabul City

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Abstract— **Today, Kabul municipality "KM" is highly dependent on landfilling method, for their disposing municipal waste materials. Where there is no an appropriate solid waste landfills system, while landfills only means as open dumpsites. The central problem in untreated landfill disposal and leachate control. Among the reasons that landfills remain a popular alternative for KM are their simplicity and versatility. The main objective of this study is to establish a standard sanitary landfill system of solid waste landfilling based on Fukuoka method (semi-aerobic landfills). this method consisted on a leachate collection pipe is set up at the floor of landfill in order to remove water from the landfill. In addition, examines the environmental impact assessment of current situation of solid waste open dumped sites, open-burning, and standard sanitary landfilling system. By examining this important environmental case, the risk of open burning and untreated landfill are much higher and will cause a lot of consequences soon at the future. The results from both case sugested that the current parcticing landills must stop immediately and move froward for well engineering landfill system. In order to, create environmentally friendly landfills, Fukuoka landfill is a rational method that should be stimulated by municipal institutional which is responsible for solid waste management.**

Index terms- **Landfills, Fukuoka Landfill method, Environmental impact assessment.**

I. INTRODUCTION

UNEP reports that Afghanistan has no proper sanitary landfills, and is currently relying on unmanaged dumpsites for waste storage (UNEP 2003).There are several open landfills in Kabul metropolitan area which poses threat to humans' health and water resources. Nevertheless, there are no incentives policies or legal enforcement to encourage residents to practice solid waste reduction and source separation in the right manner. Indiscriminate dumping of solid waste on open space area, failure of the collection and inadequate landfilling. For instance, hospital waste, household-hazardous-waste, chemical waste and construction demolished debris materials together collecting and dumping on open space area, caused most glaring health and environmental problems. Likewise, in Kabul the Kampani dumpsite is located upstream and extremely close to a drinking water well field that may soon be expanded in order to meet the city's growing demadn for water. So the potential for cross-contamination of the water supply is significant and contaminated the groundwater, so it's the inherent consequences [3]. According to KM 95 % of collected solid waste has been landfilling without any primary treatment. Also, more than 70 % informal settlements, which have influenced a lot of landfills, additionally, there are no incineration system and nor the recycling factory [1]. Above all, it has been a primary concern for KM to improving existing landfill facilities and construction of new landfills that groundwater pollution and mitigate environmental degradation. There are increasing efforts to better manage landfills, regulate waste collection and remove the existing dumps. The objective of this study to explore the current situations of municipal solid waste MSW, well engineering design of standard sanitary landfill system, and proposing Fukuoka method (semi-aerobic landfill). Among other things, the method allows government to embark with basic design and gradually upgrade it a more sophisticated level as they achieve similar improvements in other aspects of municipal waste management.

A. Material and methods

This study intend to promote introduction and effective management of semi aerobic landfill (Fukuoka Method) of techniques for final disposal site to carry out the feasibility study of the method. Because of the important case of landfill is the availability of vacant land and has could handle several years of waste material. Semi-aerobic landfills are designed with an underlying piping system that allows air to flow inside and outside the solid waste. Data that used for this article came from KM, government and nongovernmental organizations. The methodology was structured based on three main principals which the three basic procedures that are carried out in sanitary landfills area.

B. Landfill site selection:

Site selection is the first consideration in landfill design project, all necessary criteria such as the design capacity, target lifespan, social & environmental issues, operational effectiveness, flood control system and hydrological consideration must be assessed. In order to, maintain friendly

ecosystem landfills, new sites are being engineered to recover the methane gas that is generated during decomposition, and some older landfills are being mined for useful products.

C. Fukuoka landfill method:

In a semi-aerobic landfill system, leachate collection pipe and gas venting pipes are playing a significant role. The mechanism of working system stands alone with a percolation leachate collection pipes, functioning as a blood vessels in the human body that convey oxygen and discharge leachate from the body of waste layers. The benefits of this method are decomposition of organic waste is a bit faster than that of anaerobic system, likewise, offensive odour disappears, and technology is simple and easy to maintain if the concept is fully understood [7] .

Environmental impact assessment of landfill:

The environmental impact assessment includes managing the necessary activities related to preserving and protecting the environment, such as monitoring the leachate and gasses emissions, controlling the effluent discharge after treatment, prevention of scavenger and propagation of insects, preserving the aesthetic and harmony of the surrounding, etc. It is important to consider the potential impact the landfill will have on the surrounding environment such as the air quality, water, noise levels, vibration and disturbance, odour, and other source of pollution. An extensive survey of air pollution has conducted on Kabul, evaluated the more cause and source of air pollution and environmental deterioration, resulted from, found that 32 % of Kabul air pollution has caused by open burning dumping sites [10]. Emission of landfill gases and global warming, analysis by "Co-benefits Evaluation Tools" software for analysis of landfilling, open-burning and incinerations. In consequence, based on asimulation results of air pollution of landfill system; Fukuoka landfill system has the less negative impact, and it's cost-effective, applicable, less amount of budget required [10]. Landfills generate methane, it is logical to use the gas for energy generation rather than emitting this highly potent greenhouse gas to the atmosphere [13].

Overview of MSW Scenario in Kabul city

As there is no existing laws and regulations or guidelines to practice and establish a solid waste management in KM and all over the Afghanistan for tracking MSW. KM has been trying to manage their own solid waste problems by what they could with limited resources. Lack of accountability, transparency, unwilling citizen engagement in municipal operations and wrong practice has made it difficult to analyze the performance of the new system. In Kabul city residents are just discharging their waste at the nearest collection without storage or separation at home, then once a weekdays, department of sanitation DoS collecting and transporting by vehicles to a disposal site in Chimtala for open dumping [2]. There are two kinds of the collection at present: 1- open collection where residents putting their wastes to a CP that located close to their houses, afterward, separating by scavengers wastes are spread widely to the road wastes, spreading bad smells and finally deteriorating the environment. 2- Container collection, this system recently developed as a pilot project in three districts, residents are trained and getting awareness to disposal their wastes into containers, after that both the old and new collection systems will be compared and evaluated regarding efficiency [KM]. Recently it is estimated the amount of waste generations in Kabul city 6500 M3/day and collection are 4500 M3/day. The large uncollected amount of solid wastes neglected on the informal area due to narrow streets and top of hillsides where not accessible for vehicles. The characteristics rate of solid waste is 0.4 kg/c/d perhaps it will increase as living standards improving while [2]. In most cases, the largest percentage of waste is food 54.2 % or biodegradable in nature, which suggests that composting or other treatments for organic waste would have a significant impact in reducing the amount of waste entering landfills

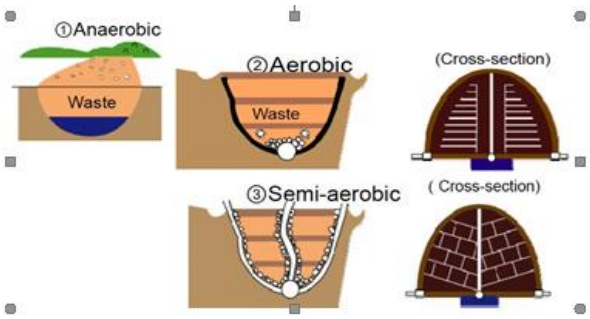
Fig 1. Current situation of landfills which is only mean as open dumped site, in Kabul city [3]

Fig 2. Current situation of solid waste collection points, in Kabul streets [3]

II. Case study of Fukuoka landfill method

A. Fukuoka Method (Semi-aerobic*)*

Fukuoka method landfill is the best solution choice of landfill system to replace open dumpsite. This landfill system was developed in a joint study by Fukuoka University and Fukuoka City in Japan. This method is specially designed for temperate climate and has been adopted in Japan and in tropical countries, such as Malaysia, Indonesia, China, Sri Lanka, and Iran, since 1980s. A schematic diagram



B. Mechanism of Semi-aerobic Landfill

A semi-aerobic landfill is a landfill manner where waste goes through a decomposition process in the presence of oxygen. Decomposition progress rate of solid waste largely depend on waste characteristics. Physical decomposition occurs during the operational management of solid waste landfill and includes segregation, mechanical size, and volume reduction. Chemical decomposition involves combustion, pyrolysis, and gasification. Biological decomposition includes aerobic and anaerobic degradation. Biodegradation generate highly contaminated hazardous leachate and gases [8]. This type of landfilling method has several advantages including reduction landfill gas and faster stabilization of the waste into the landfill. Additionally, the quality of leachate was improved at a much faster rate, and the generation of methane, hydrogen sulphide and another rest of gasses was reduced significantly (A road to Semi- aerobic Landfill, 2010). In a semi-aerobic landfill, the leachate collection system consists of a central pipe with branch pipe on either side of enough spacing. Each pipe has many holes approximately around one inch, for, the purpose of water entering and air reaching to the waste layers. The pipes should be install quite well-engineered and laid slope to allow easier collection of leachate and covered with (10 to 15 cm in diameter) rocks [6]. For more details about each type and their functionality, refer to above figure 3. In addition, comparing of three types of the landfill; it well-recognized that (anaerobic have low construction cost as well as low maintenance but it has a negative impact on the environment an
public health. Unlikely aerobic construction and maintenance cost are too high. Moreover low negative impact the environment and public health. Last of all, the semi-aerobic landfill have medium construction cost, low maintenance as well as low negative impact the environment and public health that the advantages are more than to disadvantages. So it seems more practical and applicable. Therefore, semi-aerobic landfill sounds reasonable which can transform a large portion of solid waste to the examine landfill. Consequently, based on three evaluation factors semi-aerobic method is an appropriate method for KM to consider as solution concrete manner [12].

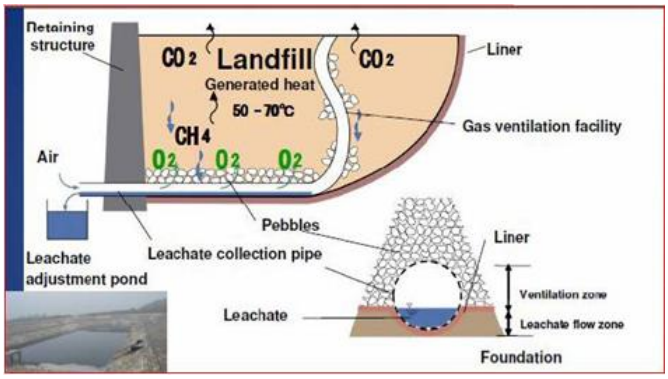


Fig 4. Schematic diagram of a semi-aerobic Fukuoka landfill method [7]
(Source: Matsufuji and Sinha. 1990.)

C. . Key Advantages of Fukuoka Method (Semi-aerobic) Landfill type

The beneficial of this is include but not limited as those pipes act like blood vessels that convey oxygen(air) and discharge leachate from the body (waste layers) [8]. Leachate is discharged as soon as it is collected in pipes, thus reducing water pressure and the likelihood of seepage. Fresh air is naturally brought in through the solid waste; it makes the waste stabilization and the leachate purification in a short time. The emission of methane is reduced although that of carbon dioxide increases, and it is simple-tech, it can be install and operate easier with a low degree of technical demand, machines, devices and easiest operation and maintenance, as well as cost effective and initial investment is low which fear is for KM. Finally, it helps mitigate global warming by reducing the amount of CH4 and (25 times more harmful than CO2) produced [8, 13].

III. Environment Impact Assessments of Landfilling

Kabul city environment is under great pressure of uncontrolled solid wastes, uncollected solid waste, illegally dumping, open burning of solid waste and dust from unpaved roads caused outrage and deteriorating the normal live conditions for citizens of Kabul. Landfills are involved the buried disposal waste on land with little or no pre-treatment to reduce waste sending through to landfills. An air pollution survey had conducted in Kabul, a high percentage of the air pollution 32% has caused by open burning solid waste which is not acceptable, and people are very affected by this harmful air pollution accordingly [10]. Meanwhile, solid waste has been collecting at open dumping sites on the occasion of landfilling. Unfortunately, that dumpsites remaining for a long time while became smelly and as an eyesore on surrounding area after that burning or firing by local people or municipal staff which is not acceptable anymore. On the other words, the landfill gas is the natural byproduct of the decompositionof solid waste in landfills, it primarily consist of CO2 and CH4. Well established, low-cost methods to reduce greenhouse gasses from consumer waste exist, including recycling program, waste reduction program, and landfill methane capture programs. People suffer many nuisances that caused by landfills. This

approach is used co-benefits evaluation tool for appropriate measures environmental impacts including greenhouse gas (GHG) emissions and air pollutants accompanied by waste management technologies including incineration, landfilling, composting, and anaerobic digestion and recycling. Of course, landfills produce methane, a GHG with 21 times the warming potential of carbon dioxide [10, 13].

Landfill Gas LFG

LFG is generated by the decomposition of organic solid wastes such as garbage, garden wastes, and paper products. This process may continue for 20 to 50 years after initial dumping of the MSW. At near steady-state conditions, LFG is typically composed of approximately 55 percent CH4, 40 percent CO2, 5 percent N2, and smaller amount of the rest of smaller amount of other gases.

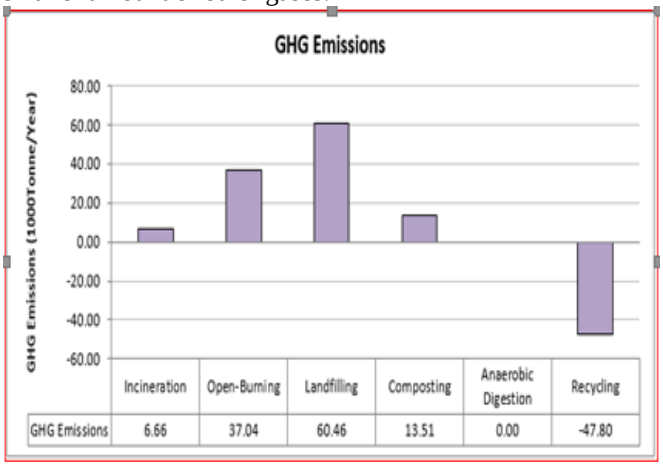


Fig 5. Source of air pollution in Kabul [10]

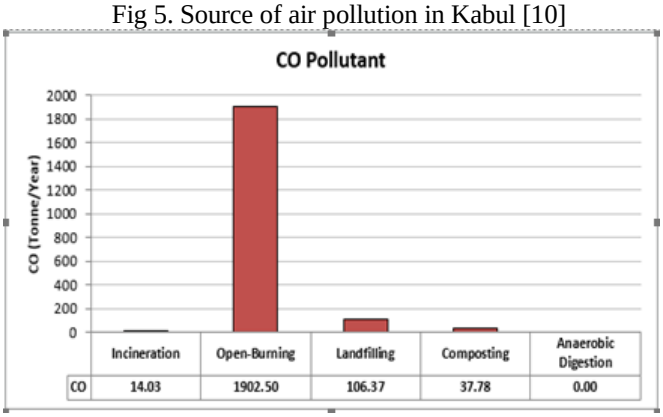


Fig 6. CO air pollution [13]

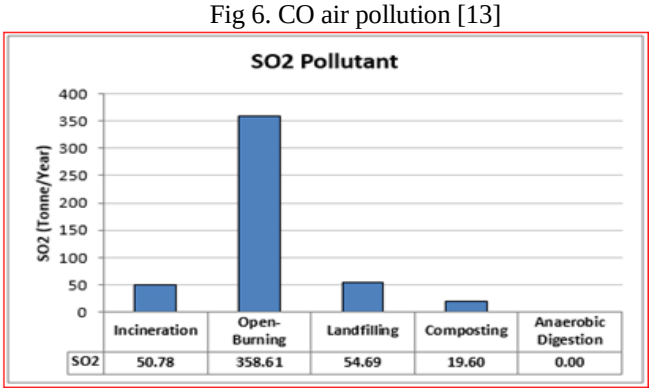


Fig 7. SO2 air pollution [13]

As figure 5 above shows, the landfill has the highest amount of GHG emission almost 60,000 ton/year, it is the provision of waste transportation, the operation of machinery and composting which is acceptable not more than 40 % according to EPCC law. In addition, GHG from open burning is 37040 ton/year which is a very crucial and potentially are the source of GHG emission related to MSW treatment. In figure 6 open-burning has created much more CO pollutant than landfills, resulting from baseline scenario of existing situation. On the other word, if KM is going straightforward toward semi- aerobic landfilling the amount of open burning will become zero which is quite reasonable and mitigate dramatically the GHG and CO2 emissions [13]. According to above figure 7, it seems open-burning has a maximum sulphur dioxide air pollutant in comparison to landfill and composting system.it has to mentioned that under no circumstance can practice any more solid waste open burning, in so far a serious consequence the environment and climate change. The result of simulation has shown that open burning are within a large amount of GHG, CO, and SO2, yet it much higher than expectation. So, frankly, the municipality needs to reconsider and take some appropriate action against the future more consequences from open burning and overall uncontrolled solid waste.

IV. Result, Discussion, and Recommendation

A. Improving Existing Landfill Facilities

There is no exist any proper sanitary landfill system and nor have taken pace toward improving landfills. In Kabul city, the existing landfill is in the worst situation as meant only as an open dump, people demonstrated and want to close or abandon the open dumpsite on Chimtala district 17 where currently the whole solid waste of Kabul city disposal and accumulated right there. All the solid wastes collected in the Kabul city are transported directly to the open dumped sites, as shown in figure 1and 2. The reasons are that the capacity to properly manage the existing landfill has not been yet improved in Kabul municipality to fulfill the common wish to harmonize solid waste within environment. By improving existing landfill situation; KM will thus, overcome some challenges and alleviate the environmental deterioration simultaneously increasingly solve the health problems and risk. According to, Kabul city master plan that conducted and prepared by JICA engineering team, they have specified five places around the suburbs of Kabul city for future proper landfill system, to enable municipality disposal at the nearest dump site of the solid waste from the city. Of course, these facilities should be designed, operated and monitored to ensure compliance with role and regulations [2, 3].

B. Design of Sanitary Landfills

Improvement of existing landfill only possible until such time municipal staff acquire enough knowledge and experience on how to properly manage and maintaining existing landfills. Following steps are required tasks for assessment of existing landfills. Space estimate, and management plan. Similarly, an access road is a necessary part of facility plan to be suitable for

vehicles to allow all- weather conditions. Also, drainage facility should be installing to reduce the amount of surface water drainage into the landfill area [7]. However, the whole the design process and upgrading landfill to explain in details here; is out of space in this paper; so, I just described flow diagram in brief as depicted in figure 8 to following stages.

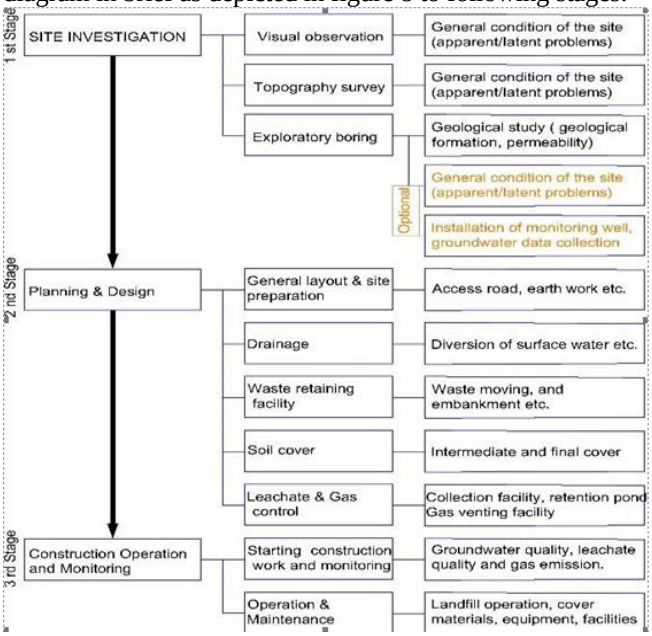


Fig 8. Flow process of landfill upgrading work [7]

C. Installation of Leachate Control Pipe

The leachate collection pipes working as some advantages: leachate pipe collection to drain the water into a retention pond, preventing it from fouling in the waste material; to protect leachate pipe from any harm and to damage during operation the collection pipes should be cover by rocks. Of course, in the semi-aerobic landfill system the leachate pipe can also act as air supply into waste layers, in other words, enhances the entire gas venting processes as the whole working system shown in the below figure 8. In simple terms, semi aerobic (Fukuoka-type) landfill is a constructive way for improving existing open- dumpsite in Kabul city as at first at the first conducting a feasibility study for upgrading the dumpsite,and then seeking funding to implement findings. While this is low cost, low technology method, easy installation, which is being spread out into all Asian countries when the result is good. To create a good environment and alleviate the health born disease and mitigate the climate change, KM has needs tend to adapt this method and study about it as a solution way [8].

D. Beneficiation of Landfills

A sanitary landfill is a site safely to isolate waste from the environment by, burying until the waste is to remove immediately and reduced the volume. In Kabul city wastes spread out everywhere on open space area, along the streets and filled the ditches. As ditches can only work as a dumpsite so, waste became for people displeasure and eyesores [3]. In this approaches; intend to examine promulgation of semi-aerobic landfill type, which is known as “the Fukuoka method landfill. So far, the vast majority of countries practicing this method where environment and waste may be considered more thoroughly. Semi-aerobic landfill method distinguished by two pipes, which those pipes function to leachate collection pipes and gas venting pipes, acting like blood vessels that convey oxygen (air) and discharge leachate from the body (waste layers).The main goal of this study tend to transfer this method in Afghanistan, improving existing conventional landfills, more importantly improving future landfill system in Kabul city, after comprehensive environmental impact assessment on landfill sites [5]. Live Cycle Assessment LCA applied in the tool for estimating the environmental impacts of waste that are including GHG emission, air pollutions, and environmental impact of the technology as well as based different scenarios. It is analyzed based on Kabul solid waste scenario in which open-dump and open- burning. The total SWM production calculated according to population and waste rate generation (0.4 kg/cap/day) which are the entered as input data in this software. The simulation results suggest that the semi-aerobic landfill type may give us greater advantages for environment protection. Lessons should be learned from the present practice of solid waste landfilling in Kabul city. The presence of large amounts of rotting solid waste matter seriously degrades the urban environment. Improvement in SWM is expected to reduce disease, ameliorate individual and public health problems and improve the efficiency of sanitation and drainage systems [4].

V. Conclusions

As KM is highly dependent on landfill system for solid waste disposal, initially, they are seeking for standard landfill method to substitute for existing landfill system. Adaptation a standard sanitary landfill for long time solution is necessarily required, to immediately disposal the waste, keep clean the environment and mitigate the risk of pollution. This case study concludes that by presenting the development of Fukuoka landfill method as a concrete solution manors for KM to substitute or the alternative to the current situation of open-burning and open-dumpsite, its best option for long-term solutions, the municipality must consider this option and adapt respectively. The simulation result shows very clearly the high amount of open-burning CO2 and SO2 air pollutions than to comparison within the landfilling system, in this case, sanitary landfill air pollutions are very low and could be neglected which is acceptable according to codes. These results suggest that the semi-aerobic landfill type may give us greater advantages for environment protection and integrated solid waste management. Improving of good quality of the environment and solid waste is a common wish which is equally important for Kabul’s residence as well as Kabul municipality to get rid of the wastes from the cities and protect the environment from the contamination by solid waste or liquid waste.

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