Assessment of Integrated Waste Management Systems in Kandahar City, Afghanistan

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***Abstract*—Life Cycle Assessment (LCA) of current MSWMS for Kandahar City and two developed integrated waste management systems (IWMSs) were carried out. In addition, field survey was performed to find out the composition of MSW in Kandahar City as this was the base line data for the LCA's. Field survey at the MSW disposal site of Kandahar City revealed that physical composition of food waste was low (26.89%) and inert (soil, sand, brick, etc.) was high (39.72%) because of constructional activities, and street and canal cleaning. LCA of current MSWMS was carried out with inclusion of fuel energy production, transport, burning used engine oil obtained from vehicles maintenance, and MSW degradation in its system boundary. The result showed that environmental impact potential for global warming, ozone depletion, terrestrial acidification, freshwater eutrophication, human toxicity, photo oxidant formation and particulate matter formation were 1504.6 kg CO_2 equivalent, 13 g CFC-11 equivalent, 1.11 kg SO_2 equivalent, 645 mg P equivalent, 28.77 kg 1,4-DB equivalent, 0.46 kg C_2H_4 equivalent plus 2.11 kg NMVOC, and 0.55 kg PM_{10} equivalent, respectively, per functional unit (FU). MSW degradation and transport were the processes mostly contributing to potential environmental impact. In scenario 1, recycling (RC) avoided energy and raw materials consumption for new production. It could reduce 10.6% (159.3 kg CO_2 equivalent) global warming potential (GWP) compared to base scenario. In scenario 2, in spite of recycling, anaerobic digestion was included to recover energy and compost. Scenario 2 showed reduction of 32.6% (490 kg CO_2 equivalent) GWP compared to base scenario. Hence, scenario 2 was a better IWMS in term of environmental sustainability to be considered by decision makers in Kandahar City.**

***Index Terms*—Integrated Waste Management Systems (IWMSS), Global Warming Potential (GWP), Greenhouse Gases (GHGS), Kandahar City.**

I. Introduction

Environmental problems which are now beyond the assimilation capacity of the Earth are induced by the increasing population of the world and higher standard of living. These problems are more evident in poor and developing countries compared to developed country because of no technology for cleaner production and lack of management in poor countries [1].

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. The city is disposing its municipal solid waste (MSW) in a primitive manner, open dumping, which is not a sustainable MSW management system (MSWMS) [2].

The management of MSW developed from simple dumping to waste-to-energy schemes or integrated methods of management which are considered sustainable [3]. Evaluation of the management systems for environmental sustainability is performed by LCA.

LCA is a tool for measuring the environmental performance of products through its life cycle that is from cradle to grave, including material recycling if required. The most significant applications for an LCA are identification of critical stages in the life cycle of a product for improvement, analyze for contribution load of each stage, comparison of products, and defining the standard for easy decision making [4].

The application of LCA proved to be successful for environmental impact assessment of MSWMSs, comparison of the management systems and evaluation of integrated MSWMSs [5, 3, 6, 7, 8, 9] and contribution of individual waste fractions to the environmental impacts from landfilling of MSW [10, 11, 12].

This study evaluates the current MSWMS of Kandahar City and compares it with two developed (IWMS) scenarios. Current management system for MSW in Kandahar City is controlled open dumping that is MSW is compacted and covered by soil regularly but no lining and leachate collection systems and top covering.Kandahar City, economic center of the southwest zone of Afghanistan, has arid climate and the average altitude of 1010 m. Kandahar City is laid in area of about 250 km^2 out of total territory of the province which is 54845 km^2. Kandahar City has 409,700 registered settled population with a 7.27% repatriating Afghan migrants in 2013 [13] some internally displaced persons (IDPs) and unregistered settled population that make the city population about 850,000 [14].

The result of this study reveals the environmental profile of Kandahar City's MSWMS and environmental advantages of IWMSs so that decision makers have enough information to choose which management option fits better for Kandahar City in term of environmental sustainability.

II. Methodology

LCA of current MSWMS of Kandahar City and of the two developed scenarios need determination of MSW composition. Hence, a six-week field survey at the disposal site of the city was conducted to determine the composition of MSW according to cone and quarter methodology from 15 December, 2014 to 31 January, 2015.

Published on August 18, 2019.

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DOI: http://dx.doi.org/10.24018/ejers.2019.4.8.1450

A. Cone and quarter methodology

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. Cone and quartering is done as follows:

1. Consolidate waste in communal bins into uniform pile, or select random load of waste delivered at disposal site;
2. All bulky items are separated from the load, categorized, weighed, and recorded;
3. The remaining material (including debris and soils) is mixed by mechanical shovel, or by hand using rakes or shovels, into a uniform pile approximately 0.8 meters high;
4. The pile is divided into two by a straight line through the center of the pile;
5. The pile is further divided by a second line roughly perpendicular to the first;
6. Either pair of opposite quarters is removed, leaving half the original sample;
7. Steps 3 through 5 are repeated until the manageable amount of sample material remains;
8. Sample weight and volume are recorded to know the density;
9. The wastes are sorted out into pre-selected categories;
10. Each category of component is weighed separately and recorded to know the composition percentage by weight [15].

B. LCA methodology

The LCA methodology was based on the ISO 14040 [16].

1) Goal and Scope Definition:

The main objective of this study was to profile the environmental impact of the current MSWMS (base Scenario) of Kandahar City and compare it with the two developed IWMS scenarios.

Base scenario includes the production of fuel which is used for collection, transportation, spreading and compaction of MSW; transport; MSW degradation and burning waste engine oil that comes from the maintenance of the vehicle fleet. The construction and maintenance of the site, decommissioning of the site, leachate, formal recycling, capital machinery such as vehicles and etc. are not considered in inventory analysis. The functional unit was 1 ton of mixed collected municipal solid waste.

First developed IWMS (scenario 1) includes the base scenario plus recycling of 50% recyclable materials (paper, plastic and glass) from the disposal site based on the composition of MSW achieved from the field survey. Office paper, polypropylene (PP) plastic and white glass are set as the representatives of waste paper, plastic and glass, respectively, for recycling processes. Only transportation and energy are included in the recycling process. Recycling 1 ton of waste paper needs 2 GJ heat and 1.5 GJ electricity for de-inking process [17]. One ton of waste plastic recycling requires 13.6 MJ electricity and glass recycling consumes 394 MJ electricity and avoids 1416 MJ per 1 ton of waste glass [18]. Lost in recycling of waste paper, plastic and glass are assumed 15%, 10% and 10%, respectively. In each recycling process transportation of the recyclable material from the disposal site to factory is 20 ton × km as the recycling is possible near the city at the industrial park and transportation of virgin materials to the factory is 500 ton × km since raw materials are not available nearby. The flow charts for recycling recyclable materials are shown in Figure 1.

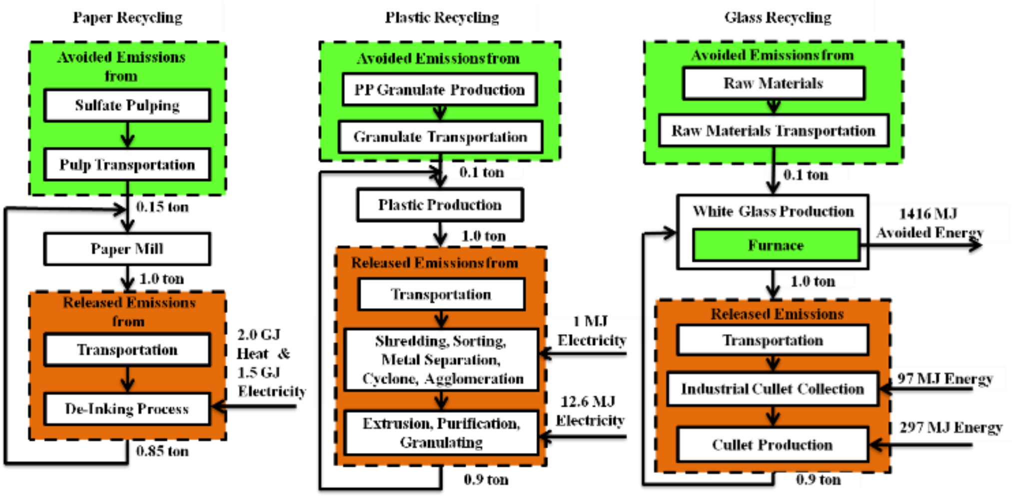

Fig. 1. Process flow charts of recyclable materials

Second developed IWMS (scenario 2) includes base scenario plus recycling of 50% recyclable materials and anaerobic digestion of 50% food waste from the disposal site. Recycling process in this scenario remained the same as in scenario 1. The anaerobic digestion includes recovery of energy (electricity and heat) and compost, and greenhouse gases (GHGs) prevention that would be emitted from food waste if it were to be dumped openly. Figure 2 shows the system boundaries for the three scenarios. The dashed vector and rectangle in base scenario indicate that the activities are not directly involved.

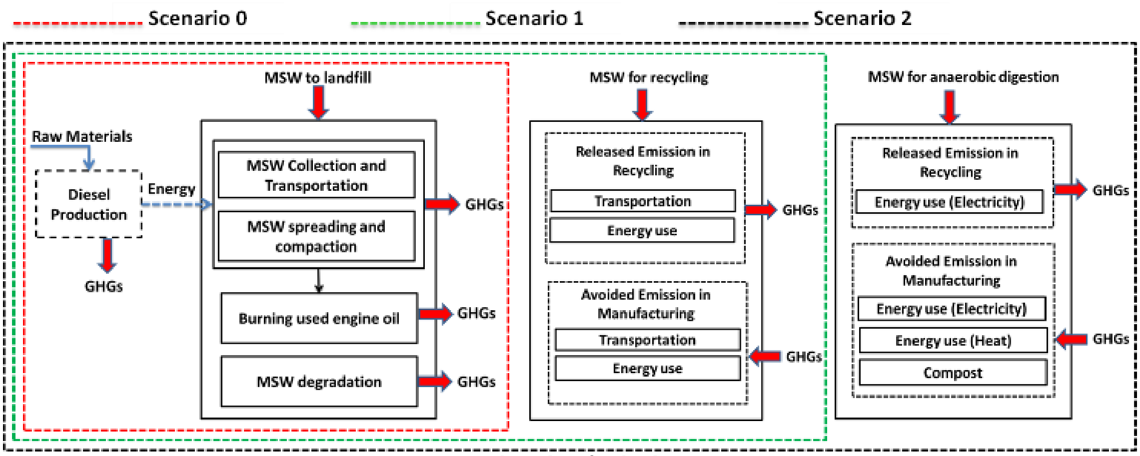

Fig. 2. System boundary for the three scenarios

2) Inventory Analysis:

The inventory of MSW degradation was done by LandGEM version 3.0.2. LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The model provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U. S. landfills [19]; hence, the defaults values were set to best fit the conditions of Kandahar City. For example, as the city is considered arid area, the value (CAA Arid Area – 0.02) was chosen for the methane generation rate rather than the default value which is (CAA Conventional – 0.05). In addition, for the potential methane generation capacity the value of 85 m^3/Mg is chosen instead of 170 because the landfill type in this study is open dumping not sanitary landfill [20]. The none methane organic carbon (NMOC) concentration is chosen CAA-600 (ppmv as hexane) because there were no hazardous components in the composition of MSW in Kandahar City [19]. Totally, 51 pollutants and gases are included in the model. The inventory of burning waste engine oil was calculated from emissions factors for combustors from AP 42 [21]. The fuel production and transport inventory in the base scenario were calculated by SimaPro 8 faculty version. In addition, inventory of paper pulp, plastic granulate, white glass production, energy (electricity and heat) and fertilizers were calculated by SimaPro 8.

3) Impact Assessment:

Climate change, ozone depletion, terrestrial acidification, freshwater eutrophication, photo oxidant formation, human toxicity and particulate matter formation were the selected impact categories in this study. The classification and characterization of inventory from MSW degradation and burning used engine oil were done manually from the literature review while the rest of life cycle inventory (LCI) were classified and characterized by SimaPro 8 software with ReCiPe midpoint methodology. The units used for characterization of photo oxidant formation are kg C_2H_4 equivalent and kg NMVOC (used in SimaPro 8). The units kg CO_2 equivalent, kg CFC-11 equivalent, kg SO_2 equivalent, kg P equivalent, kg 1,4-DB equivalent, kg PM_{10} equivalent are used for characterization of climate change, ozone depletion, Terrestrial Acidification, freshwater eutrophication, human toxicity and particulate matter formation, respectively.

III. Result

A. Composition of MSW

Field survey for composition of MSW was carried out for six weeks at different days of the week to better present the composition. In addition, Kandahar Municipality was asked about the data regarding MSW. Although it was winter season and the average high temperature was about 14 degrees Celsius, no precipitation occurred during the survey. The sources of MSW in Kandahar City are residential areas, commercial areas, institutions, street sweepings, and canals and drainages cleaning. Average annual generated MSW in the city was 264146 tons (458586 m^3) and 52% (137918 ton) was collected and disposed of at disposal site. Composition of MSW at the disposal site in Kandahar City are summarized and shown in Table 1.

TABLE 1: MSW COMPOSITION OF KANDAHAR CITY

Composition	*Percentage*						
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Average
Organic Waste	26.8	24.3	29.1	27	25.4	28.7	26.89
Yard Waste	0	0	0	0	0	0	0
Textile	2.2	1.7	2.5	1.5	1	1.6	1.75
Paper & Cardboard	1.6	2	3	1	1.7	1.8	1.85
Wood	1.3	1	0.9	1	0.7	1.5	1.07
Plastic	12.3	13.1	15.9	12	9.4	11.8	12.42
Glass	2.3	3.3	4.1	2.9	3.4	2.7	3.12
Metal	0.2	0.7	0.2	0.5	0.4	0.2	0.37

DOI: http://dx.doi.org/10.24018/ejers.2019.4.8.1450

Hazardous	0.2	0.2	0.2	0.1	0.2	0	0.15
Miscellaneous (not separate able)	12.6	12.9	14.6	12	10.7	13.3	12.69
Inert (stone, brick, dust, sand, etc)	40.5	40.8	29.5	42	47.1	38.4	39.72
Total Weight (kg)	90	78	62	100	75	68	79
Total Volume (m3)	0.153	0.132	0.117	0.171	0.129	0.117	0.137
Density (kg/m3)	588.3	591	530	584.8	581.4	581.2	576.1

The variation in composition of MSW depends on geographical location, climate, economy, literacy, culture and population of a city. Kandahar City has dry hot climate and the annual precipitation is 178 mm [22]. The city covers an area of 250 km^2 and had GDP per capita of $ 678 in 2013 [23]. The city population is around 850000 and 32% of it is educated. It is revealed that Kandahar City has denser MSW mainly because of the construction waste such as bricks, soil and sands and hence the MSW generation per capita is higher (0.85 kg).

B. LCA of the MSWMSs

1) Base Scenario

The consumption of fuel per functional unit was 1.71 liter of diesel and the waste were transported 632 ton $\times$ km by vehicles equivalent to Euro 2 standard. The vehicles were of the size equal or less than 10 tons. The loading factor for vehicles was 100% and the vehicles were returning back empty to the city after unloading the waste at the disposal site. The volume of waste engine oil per functional unit was 0.05 liter. The characterized inventory for the four stages included in the system boundary of base scenario's LCA is shown in Table 2.

TABLE 2: POTENTIAL ENVIRONMENTAL IMPACT OF BASE SCENARIO

Impact Categories	Compartment	Unit	Diesel production	Transport	Burning used engine oil	MSW degradation	Total/FU
Climate Change	Air	kg CO_2 eq.	0.89	203.72	0.14	1299.84	1504.59
Ozone Depletion	Air	kg CFC-11 eq.	3.8×10^{-7}	4×10^{-7}	0	1.29×10^{-2}	1.3×10^{-2}
Terrestrial Acidification	Air	kg SO_2 eq.	2.7×10^{-3}	1.1	6.2×10^{-4}	1.76×10^{-2}	1.11
Freshwater Eutrophication	Water, Soil	kg P eq.	1.88×10^{-6}	6.28×10^{-4}	1.5×10^{-5}	0	6.45×10^{-4}
Human Toxicity	Air, Water, Soil	kg1,4-DB eq.	6.02×10^{-3}	4.39	6.45×10^{-1}	2.37×10	2.88×10
Photo Oxidant Formation	Air	kg C_2H_4 eq.	-	-	1.19×10^{-6}	4.56×10^{-1}	4.56×10^{-1}
		kg NMVOC	5.69×10^{-3}	2.11	-	-	2.12
Particulate Matter Formation	Air	kg PM_{10} eq.	8.8×10^{-4}	5.44×10^{-1}	4.5×10^{-4}	0	5.45×10^{-1}

MSW degradation at disposal site was the most contributing stage of current MSWMS to climate change. Its GWP was about 1300 kg CO_2 equivalent when not including CO_2 emission and considering characterization factor for methane to be 24, not 25, because they were of biogenic sources; otherwise, the total emissions of landfilling would be 1549.25 kg CO_2 equivalent. The climate change impact of MSW degradation can be higher if MSW is sanitary landfilled and there is no installed gas recovery system because then larger portion of GHGs would be methane which has higher GWP. In the stage of MSW degradation, methane and carbon dioxide are high in volume while methyl chloroform, carbon tetrachloride, chlorodifluoromethane, dichlorodifluoromethane and fluorotrichloromethane are less in volume but have higher climate change potential. Transport emissions contributed second the most to global warming which was 203.718 kg CO_2 equivalent per functional unit mainly in the forms of carbon dioxide and dinitrogen monoxide gases.

Current management system has less impact on ozone depletion which was 13 g CFC-11 equivalent per functional unit mainly from the MSW degradation stage. Gases like methyl chloroform, carbon tetrachloride, chlorodifluoromethane, chloromethane, dichlorodifluoromethane and flourotrichloromethane cause ozone depletion. Impact on terrestrial acidification per functional unit was 1.11 kg SO_2 equivalent in total which is contributed mostly by transport section. Ammonia, nitrogen dioxide/s and sulfur dioxide contributed in this impact category. Impact on freshwater eutrophication was 645 mg P equivalent which was mostly dominated by transportation which is releasing phosphate to air and water. The impact on human toxicity and photo oxidant formation were mostly contributed by landfill, transport, burning waste motor oil and diesel production, respectively. Particulate matter formation impact was ruled by transport and fuel production while MSW had no impact in this category.

This LCA had some limitations. For example, the LCI for the diesel production and transport were derived from SimaPro. However, attempts are made to select the proxy and closer options with accordance to the conditions and usage pattern of fuel in Kandahar City. In case of burning used engine oil, individuals may not burn the oil in combustors which are assumed in this study for getting the emission factors. Likewise, LCI of MSW degradation was with some assumptions that in no conditions it can be guaranteed that LandGEM has calculated the actual gases and pollution which can be emitted from the open dumping of MSW in Kandahar City.

2) Scenario 1

The amounts of recyclable materials per functional unit based on the data from the field survey are shown in Table 3.

TABLE 3: COMPOSITION OF RECYCLABLE MATERIALS IN MSW OF KANDAHAR CITY

No.	Components	Percentage	Amount/FU (kg)	Recovery (50%)/FU (kg)
1	Paper	1.85	18.5	9.25
2	Plastic	12.42	124.2	62.1
3	Glass	3.12	31.2	15.6

TABLE 4: POTENTIAL ENVIRONMENTAL IMPACT OF WASTE PAPER RECYCLING

Impact category	Unit	Paper	Plastic	Glass	Total
Climate change	kg CO2 eq.	-1.434	-150.98	-6.91	-159.324
Ozone depletion	kg CFC-11 eq.	0.01	0	0	0.01
Terrestrial acidification	kg SO2 eq.	-0.02	-0.36	-0.05	-0.43
Freshwater eutrophication	kg P eq.	-0.01	-0.01	0	-0.02
Human toxicity	kg 1,4-DB eq.	0.03	-0.33	-0.22	-0.52
Photochemical oxidant formation	kg NMVOC	-0.05	-0.53	-0.05	-0.63
Particulate matter formation	kg PM10 eq.	-0.03	-0.14	-0.02	-0.19

TABLE 5: POTENTIAL ENVIRONMENTAL IMPACT OF SCENARIO 1

Impact category	Unit	Total
Climate change	kg CO2 eq.	1345.266
Ozone depletion	kg CFC-11 eq.	0.023
Terrestrial acidification	kg SO2 eq.	0.681
Freshwater eutrophication	kg P eq.	-0.02
Human toxicity	kg 1,4-DB eq.	28.24
Photochemical oxidant formation	kg C2H4 eq.	0.456
	kg NMVOC	1.486
Particulate matter formation	kg PM10 eq.	0.360

The emissions from 0.85-ton pulp production and its 500 km transportation which were avoided were summed up with emissions from 1.5 GJ electricity, 2 GJ heat and 20 km transportation to give the net potential environmental impacts of 1-ton waste paper recycling. Likewise, the avoided emissions of transportation and 0.9 ton of granulate production was allocated with released emissions of transportation and 13.6 MJ electricity generation to present environmental impact of 1-ton plastic recycling. It is assumed that glass production is from 70% virgin materials and 30% recycled cullet before recycling is introduced. By recycling the waste glass, percentage of virgin material use is reduced to 10%; therefore, it needs less energy in furnace of glass production factory for melting. The emissions avoided by reducing virgin materials and from avoided energy (1416 MJ electricity) are summed up with the released emissions from transportation and energy (394 MJ electricity) to have potential environmental impact for 1 ton of waste glass recycling. The impacts of recycling are calculated for functional unit and are shown in Table 4. Total potential environmental impact of scenario 1 per functional unit is shown in Table 5.

3) Scenario 2

The calculation for recovery of energy and compost from anaerobic digestion was done based on the data from plants in Thailand [3]. Anaerobic digestion (AD) can produce 300 L CH_4/dry kg of food waste [24]. The moisture of food waste is assumed to be 50% [25]. It is concluded that 243 MJ (67.50 kWh) electricity per functional unit, 175.58 MJ (48.77 kWh) heat/FU and 0.058-ton compost/FU is recovered from anaerobic digestion of food waste. A compound fertilizer is made of N, P_2O_5 and K_2O fertilizers. One ton of compost is equivalent to 7.1 kg N fertilizer, 4.1 kg P_2O_5 fertilizer and 5.4 kg K_2O fertilizer [26]. Potential environmental impact of the compound fertilizer equivalent to 1 ton of compost is shown in Table 6. The avoided emissions due to anaerobic digestion per functional unit are shown in Table 7.

TABLE 6: POTENTIAL ENVIRONMENTAL IMPACT OF COMPOST

Impact category	Unit	Equivalent to 1 ton compost			
		Fertilizers			Total
		7.1 kg N	4.1 kg P_2O_5	5.4 kg K_2O	
Climate change	kg CO2 eq.	92.1	16.93	12.19	121.22
Ozone depletion	kg CFC-11 eq.	0.01	0.01	0.01	0.03
Terrestrial acidification	kg SO2 eq.	0.34	0.07	0.12	0.53
Freshwater eutrophication	kg P eq.	0.01	0.01	0.01	0.03
Human toxicity	kg 1,4-DB eq.	1.32	0.12	0.29	1.73

Photochemical oxidant formation	kg NMVOC	0.18	0.04	0.05	0.27
Particulate matter formation	kg PM10 eq.	0.1	0.02	0.05	0.17

TABLE 7: AVOIDED ENVIRONMENTAL IMPACT FROM ANAEROBIC DIGESTION

Impact category	Unit	Electricity and heat	Compost	Total
Climate change	kg CO2 eq.	-85.54	-7.04	-92.58
Ozone depletion	kg CFC-11 eq.	-0.02	-0.01	-0.03
Terrestrial acidification	kg SO2 eq.	-0.54	-0.04	-0.58
Freshwater eutrophication	kg P eq.	-0.02	-0.01	-0.03
Human toxicity	kg 1,4-DB eq.	-3.3	-0.11	-3.41
Photochemical oxidant formation	kg NMVOC	-0.34	-0.02	-0.36
Particulate matter formation	kg PM eq.	-0.16	-0.01	-0.17

The amount of waste goes to landfill reduces as 50% (13.45 kg/FU) of food waste composition is used for anaerobic digestion. The amount of methane and carbon dioxide (160.8 kg CO_2 equivalent) that could be generated from the recovered food waste at the open dumping are deducted from the methane and carbon dioxide generated at the base scenario to present the environmental impact of open dumping in scenario 2. Changes in potential environmental impacts of open dumping due to recovered recyclable materials and transportation are neglected in this scenario due to their less effect on total potential environmental impacts especially on global warming potential. Table 8 shows total potential environmental impact of scenario 2.

TABLE 8: TOTAL POTENTIAL ENVIRONMENTAL IMPACT OF SCENARIO 2

Impact category	Unit	Landfill	AD/FU	RC/FU	Total/FU
Climate Change	kg CO2 eq.	1343.8	-169.83	-159.324	1014.646
Ozone Depletion	kg CFC-11 eq.	0.013	-0.05	0.01	-0.027
Terrestrial Acidification	kg SO2 eq.	1.111	-0.84	-0.43	-0.159
Freshwater Eutrophication	kg P eq.	0.007	-0.05	-0.02	-0.063
Human Toxicity	kg 1,4-DB eq.	28.756	-3.62	-0.52	24.616
Photochemical oxidant formation	kg C2H4 eq.	0.4558	0	0	0.4558
	kg NMVOC	2.1157	-0.46	-0.63	1.0257
Photochemical oxidant formation	kg PM10 eq.	0.5452	-0.27	-0.19	0.0852

GWP of base scenario is mainly because of methane production in landfilling and transportation. In scenario 1, the GWP is reduced because of the avoided or negative emissions in recycling that affected the GWP of landfill and in scenario 2 the GWP is even more reduced because of the conversion of food waste to compost and the energy recovery from anaerobic digestion.

Scenario 1 is better than base scenario in all impact categories except that ozone depletion is higher than the base scenario that is mainly because in recycling more electrical energy is used. For example, 3.5 GJ energy is used for deinking process in paper recycling which results higher potential of ozone depletion. However, scenario 2 show reduction compared to both scenario 1 and base scenario in all impact categories.

IV. CONCLUSION

The overall objective of this study was to assess the potential environmental impact of MSWMS of Kandahar City based on a life cycle prospective. The food waste composition was too low because some food waste is used for pets feeding at sources, some food waste is used by animals at the disposal areas, some is degraded at community bins before they are transported to the disposal site and some are mixed with other components that makes it impossible to be separated. In contrary, inert composition (40%) was too high because of the constructional wastes which mainly come from unpaved roads, rehabilitation of buildings and houses, and street and canal cleaning. Compositions of recyclable were less because most of them are separated by individuals from the MSW stream at the sources and some are scavenged by children at the disposal site.

LCA of current MSWMS of Kandahar City was a simplified and first-order to second-order LCA. The high emission of pollutions is due to lack of gas recovery system at the landfill, use of low standard vehicles (Euro-2) for transportation, lack of formal recycling of recyclable materials, and no introduction of waste treatment technology, for example, anaerobic digestion for food waste.

Scenario 2 is the best integrated waste management system (IWMS) for Kandahar City to be implemented since the system reduces the environmental impacts of MSW and volume of MSW at the landfill. If the food waste recovery is more than 50% at the disposal site or recovery is done at the source, the avoided emissions would be even more because in that case energy used for separation would be avoided and there would be benefits from economy of scale.

The present study did not cover all the possible options for MSWMS. In fact, more scenarios with different collection rate, recycling and anaerobic digesting percentage need to be assessed for environmental sustainability. In addition, not only environmental sustainability but also economic sustainability and government affordability have to be considered for better selection of MSWMS in Kandahar City.

V. Abbreviations

1,4 DB	1,4 Dicholorbenzene
AD	Anaerobic Digestion
AP	Air Pollutant
CAA	Clean Air Act
CFC-11	Chloroflourocarbon
eq.	Equivalent
FU	Functional Unit
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GJ	Gega Joule
GWP	Global Warming Potential
IDPs	Internaly Displaced Persons
ISO	International Organization for Standardization
IWMS	Integrated Waste Management System
LandGEM	Landfill Gas Emission Model
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
Mg	Mega Gram
MJ	Mega Joule
MSW	Municipal Solid Waste
MSWMS	Municipal Solid Waste Management System
NMVOC	Non Methane Volatile Organic Carbon
PM10	Particulate Matter upto 10 Micrometer Size
ppmv	parts per million by volume
RC	Recycling
US	United States

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