Life Cycle Assessment of Municipal Solid Waste Management System in Vyas Municipality, Tanahun, Nepal

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Abstract: The environmentally habitual management of municipal solid waste has become a global challenge. It is due to rapid urbanization, ever increasing population, limited resources and industrialization all-inclusive. According to the preliminary report of the national population census 2011, the population of Nepal reached approximately 2.7 million in the year 2011 which shows an increase of population at the rate of 1.4 percent per annum with population density estimated at 181 per sq. KMs. Solid waste management in Nepal, the current practice of the illegal dumping of solid waste on the river banks has created a serious environmental and public health problem. The focus of this study was to carry out the magnitude of the present SWM problems by identifying the sources, types, quantities, dangers and opportunities they pose. It will be helpful to examine the adequacy of the existing institutional arrangements, policies, laws and regulations and identify public and private investment opportunities then can design and implement a strategic and operational plan for SWM and to establish the EASEWASTE data base of municipal solid waste management system in Vyas Municipality, Nepal. The study showed that the major contribution (direct impact) is due to direct disposal of waste in river bank. The total quantity toxic emitted by the scenarios that caused human toxicity are 1,072,469,260.192m^3 and 411,548,307.452m^3per year with reference to EDIP97 respectively.

Keywords: *Vyas Municipality, EASEWASTE, Municipal Solid Waste, LCA*,EDIP97

1. Introduction

Due to limited resources, ever increasing population, rapid urbanization and industrialization the environmentally habitual management of municipal solid waste has become a global challenge. The urban population in developed nations was 74% of the total population in those countries, whereas the urban population in developing nations accounted for 44% of the total 7 billion in 2011.However, urbanization is occurring rapidly in many less developed countries. It is expected that 70 percent of the world population will be urban by 2050, and that most urban growth will occur in less developed countries.

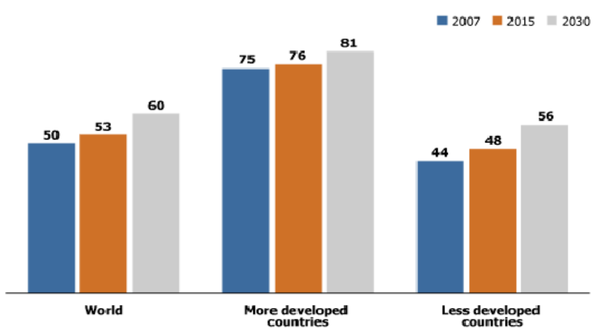

Figure 1: Percent of world urban population, 2007, 2015 and 2030(UNPF)

Nepal is undergoing a population explosion in its urban areas in recent times especially due to the rural migrants seeking employment, business and other opportunities in the cities. The urban population of Nepal constitutes about 17 percent of the total population in 2011 compared to 14 percent urban population in 2001, which is low when compared with other developing nations. However, compared to the land area of the country and the available resources, this small urban population has become an enormous burden for the government in terms of environmental health, sanitation and environmental management. The urbanization in Nepal is rapid and haphazard, creating problems in facility management. The urban population in Nepal in 2011 was approximately 4.5million (CBS, 2011). And the Urban population growth (annual %) in Nepal was last reported at 4.45 in 2010, according to a World Bank report released in 2011.

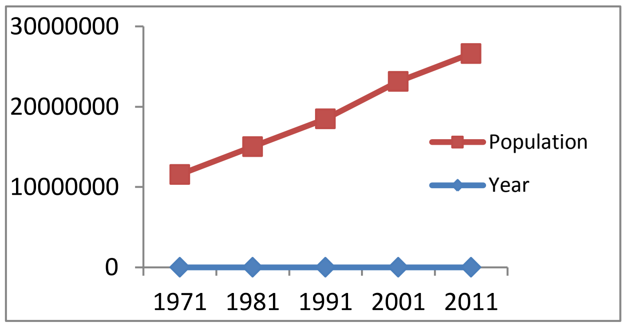

Figure 2: National populations according to censuses (CBS 2011)

Solid waste management has become a major challenge in most urban centers. Rapid urbanization and changing consumption patterns, Open waste piles are a common site and the work of municipalities' is often limited to sweeping the streets and dumping the waste in the nearest river or vacant land. Modern waste management techniques, such as source separated door-to-door collection, recycling facilities and sanitary land filling, have not yet been introduced in most municipalities and the municipalities generally do not have the necessary skills or resources to manage the waste in the proper manner. According to a survey done by SWMRMC, 21 municipalities dump their waste in river banks, 19 dump it in open piles and 10 have some sort of dumping site. Nepal consists of 58 municipalities with varying population size and living standards. Thus, the produced MSW differs MSW varies within Nepal and its municipalities. It is estimated that the total amount of municipal waste generated in Nepal is about 500,000 tons per year. Less than half of this gets collected and almost all of the collected waste is dumped haphazardly in a crude manner.

Vyas is small municipality with total coverage area of 59 square km. The municipality lies in the western development region within Tanahun district of Gandaki Zone. The municipality is connected with Prithivi highway at distance 150 km west of Kathmandu and 50 km east of Pokhara. Vyas lies in hilly region at an altitude of 310 m to 1120 m from the sea level. Vyas has mild climatic conditions with temperature ranging from 8.4oC to 37oC and with annual rainfall of 1960.6 mm. The municipality is divided into 11 ward and 132 Tole Lane Organizations (TLO). According to 2001 census, the population of the Vyas municipality was 28,245 and extrapolating that data using national growth rate of 2.24 gives the present population to be around 35 thousand. Ethnically, majority of the municipality residents are the Brahmins followed by Magar, Chettri, Darai and Newars. Majority of the people are economically dependent on business and foreign employment.

Table 1: List of the business enterprises of Vyas municipality

S.N	Business Entities	Numbers
1	Hotels	187
2	Restaurants	27
3	Sweets Shop	10
4	Clothing Store	19
5	Fancy Shops	63
6	Wool Threads Shop	6
7	Cosmetic Shops	65
8	Shoes	15
9	Constructions Materials	8
10	Food Stuffs wholesale/ retail	270
11	Utensils	24
12	Books and Stationeries	21
13	Photo Studio	8
14	Color Lab	3
15	Watch and radio	29
16	Stoves, Fan and machines	8
17	Bicycle selling and maintenance	5
18	Motor parts, workshops	17
19	Driving institute	3
20	Tyre Maintenance	3
21	Grill Industries	11
22	Tent House	3
23	Music Store(Madal)	3
24	Bio Gas and Solar	4
25	Movie Theatre	3
26	Medical Stores	20
27	Veterinary stores	4
28	Seeds store	7
29	Paints and Electrical	8
30	Furniture Shops	4
31	Gold and silver	24
32	Tailoring Shops	33
33	Hair cutting	16
34	Law firms	11
35	Petrol Pumps	2
36	Kerosene Pumps	1
37	Courier, Fax , telephone, computers	19
38	Shopping centers	3
39	Vegetable Shops	28
40	Meat Store	43
41	Glasses and spectacles	2
42	Fruits store	20
43	Dental clinics	3
44	Nursery	1
45	Bricks Kilns	3
46	Stone Crusher	2

Besides households, the major occupation of people in Vyas Municipality is business; in which majority of the enterprise belongs to service sector such as hotels and restaurants which significantly contribute to the total waste generation in the municipality. These institutions generally produce institutional waste whereas medicinal facilities like hospital and clinics generate hazards waste. Foreign employment and Agriculture is secondary occupation where they are also involved in livestock raising.

2. Waste Generation and Composition

The introduction of new materials and changing consumption patterns has resulted in increasing volumes of waste. In Nepal, as in many other developing countries, these changes have taken place rapidly over the past few decades, while the government and the people have failed to realize their serious implications and the urgent need to address them. As a result, many cities in Nepal are now suffering from the adverse impacts of unmanaged waste. The table 2 below shows the content of waste generated in different municipalities of Nepal.

Table 2: Daily solid waste generations in municipalities (CBS 2009)

Description	Kirtipur			Kathmandu			Lalitpur			Bhaktapur			Thimi		
	2000	2005	2006	2001*	2005	2006	2004	2005	2006	2003	2005	2006	2003	2005	2006
Organic	74	75	74.2	69	69	69	67.5	67.5	67.5	70.2	75	75	70.1	75	75
Paper	3		5.72	9	9	9	8.8		8.8	2.37		3.25	4.9		6
Rubber	1		0.09	1	1	1	0.3		0.15	0.05			0.55		1
Leather	2		0.87	N.A					0.15						1
Wood	0		0.09	1			0.6		0.6						
Plastic	9	9	8.83	9	9	9	11.4	15.4	11.4	3.23	6.4	3.4	8.25	20	5
Textile	6		1.92	3	3	3	3.6		3.6	1.69	3	3	2.27		1
Ferrous Metal			1.94	1	1	1	0.9		0.9	0.07		0.3	0.25		
Inert										21.1			12		
Glass	1		2.91	3	3	3	1.6		1.3	1.33		1.5	1.29		2
Others	4	16	3.39	4	3	3	5.3	17.1	5.6	0.05	18.6	2.45	0.19	5	9
Medical waste													0.2		
Const. Material					2	2						11.1			
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Average Collection %					91	91				51.3			47.2		

There are many different sources of solid waste in municipal areas. Waste comes from the residential population, commercial establishments and public and private institutions. Primary waste generators in Vyas municipality are households, shops, wet markets and hospitals/medical facilities. According to the survey conducted by Vyas on August 2007 shows generation rate to be of 0.25 KG per person per day if only the household wastes are considered.

The assessment also showed that around 75% of the wastes are organic or decomposable wastes. The remaining 25% inorganic wastes consisted mainly of paper, plastics, metals, glass, rubber, leather, medical waste and textiles. But the main stakeholders hotels, restaurants, vegetable shops dominated the household waste. Hazardous waste from the various clinics and hospitals has the significant contribution in the waste generation.

The system boundaries i.e. from the point of waste generation and the source separation to the point after final disposal of the waste residuals are defined below with collected data and information. The waste generation in Vyas municipality is 0.28 KG per person per day. According to 2001 census, the population of the Vyas municipality was 28,245 and extrapolating that data using national growth rate of 2.24 gives the present population to be around 35 thousand. Hence 9870 KG wastes are generated every day; this is equivalent to 360 tons per year. The composition of solid waste used in this research is shown in the figure 4 below. The total amount of solid waste was 360 tons per year tons per year, of which 230 tons per year, including 32.4 tons per year of waste paper, 25.2 tons of waste plastic, 10.8 tons of waste glass and so on. The sorting efficiencies of the recycled materials of the waste including plastics, paper, and glass were assumed as 20%, 60% and 80% respectively. The remaining residues are directed to the landfill which is 1km distance from the municipality.

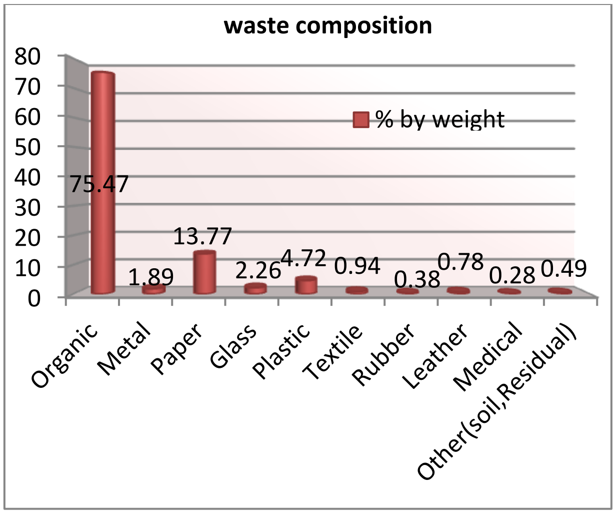

Figure 3: Physical composition of municipal solid waste (SWMRMC 2004)

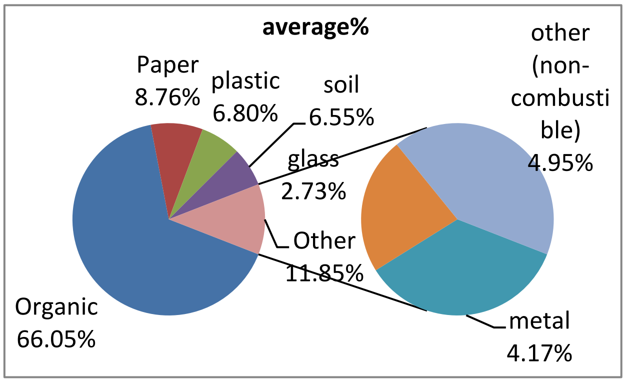

Figure 4: Average household waste composition of Vyas municipality

3. Collection/ Transportation/ Disposal Scenario

According to the ADB-2010 report municipality has not been able to collect total waste generated within the municipality. Only 24.01% waste has been collected by the municipality every day. Vyas Nagar gatibidi 2006 states that the area covered by the municipal waste collection service includes the core market area of ward no. 2, 10 and 11.Municipality has three systems for waste collection:

- door to door collection,
- container collection and
- collection from roads (public section)

Actually, there are no fixed waste collection points. But as waste is normally piled up in the same places these spots have become like regular points for collection. Since there is not enough equipment, the municipality has not been able to provide daily service even to the small service coverage area. Municipality collects wastes from households, shops, market places, streets etc. while hospital wastes are managed by hospital itself. But, the wastes from medical clinics are mixed with the general municipal wastes.

Municipal waste is dumped in the bank of Madi River. There is no any proper sanitary landfill site or dumping site as such. No precautionary measures are taken but occasionally wastes are covered by soil to stop the waste being carried away by wind. The municipal staffs also burn the wastes frequently. Some waste-pickers gather sellable recyclables from the dumping site. These waste pickers sell such recyclable goods to the scrap dealer. The dumping site lies in the distance of 1 km from the municipality office and 1 km from Prithivi highway. The coverage area of the dumping site is around 3 Ropani. The amount of waste disposed to landfill site is estimated to be around 9.87 tons per day. Problems associated with disposal in the landfill site are as follows:

During the monsoon as river water covers the bank, it is very difficult to landfill waste.

People have their land near by the dumping site so there are some conflicts. People approach municipality with complains.

Openly filled waste often litters. Plastics and paper waste get blown to the houses nearby creating problems. Similarly, street children burn these waste in the landfill site which have ill impacts in the environment and health.

4. Scenarios Description and Evaluation

Most of the institutions burn the lighter waste like paper and plastics within the premises to control the littering. Segregation of waste at household is not generally practiced but sellable recyclables such as metals, plastics and bottles are kept separately by many households. Some houses also keep the organic or decomposable wastes separately for composting. Hence almost 24.01% residual wastes go to the municipal waste management. The primary equipments for waste collection and transport are containers and tractors. Two tractors used for the transportation have capacities 5m3 and 3.78 m3. The tractor covers a distance of 3 km and runs daily for 8 hours in course of collection of waste from door to door. Beside municipality Rotract Club of Damauli is also involved in collection of wastein the city. Rotract has been mobilizing one rickshaw along with one man for the waste collection task Municipal waste is deserted in the bank of Madi River. There is no any proper sanitary landfill site. The disposed waste is covered by soil layer from time to time. Hence it falls under the conventional landfill category. The waste that is disposed in riverbank is subjected from seasonal variation. In which the disposed waste is drained way in the rainy season when the river has forceful current. Because of this phenomenon the disposed waste cannot get properly decayed. In this context the following two scenarios implicit and the environmental assessment was based on these scenarios.

Scenario 1

It is the current waste management system in Vyas municipality, in which the mixed waste sent to the landfill where LFG emissions are not treated.

Scenario 2

It considers all the Organic waste generated from Vyas municipality is sent for composting and the remaining waste is sent to the landfill.

This calculates the amount of all waste entering a process and all solid waste streams leaving a process as products or residues, the model calculates composition of the outputs from each treatment process.

a) Non-Toxic Impact Potential Categories

The lifecycle impact categories in EASEWASTE are categorized as toxic and nontoxic impact categories. The nontoxic categories include global warming potential, acidification, nutrient enrichment and the toxic impact categories, quantified as human toxicity to air water and soil as well as eco toxicity to water (chronic and acute) and soil. The main contributions to these categories depend on the cases considered but mainly were heavy metal input to water and soil. Nitrous oxide also contributes to toxicity (human toxicity; air). After normalization, the toxicity impact categories are grouped in three categories as persistent toxicity(average of normalized contributions from eco toxicity to water (chronic), eco toxicity to soil, human toxicity to water and human toxicity to soil); eco toxicity (eco toxicity to water (acute); and human toxicity (human toxicity to air) (Hansen_2 2006; Kikeby_1 2006; Bhander, Hauschild et al. 2008; DTU 2008).

Global warming potential is an important impact category in life cycle assessment modeling of waste management systems. The model calculated the load of carbon to the atmosphere, under ideal conditions. Nutrient enrichment is another impact potential category mainly derived from emissions of ammonia and nitrate. It aggregates all nutrient enriching emissions into SO_2equivalences (kg SO_2). The large contribution to nutrient enrichment is mainly from the surface run-off of nitrate and ammonia volatilization. Ammonia volatilization is mainly due to high ammonia content (Hansen_2 2006). Acidification is mainly caused by ammonia volatilization in the scenarios. This impact category aggregates all emissions leading to acidification into SO2 equivalences (kg SO_2). Since anaerobically digested MSW contains significantly more ammonia than composted MSW, it results more contribution to acidification. Photochemical ozone formation aggregates all emissions leading to photochemical ozone formation into C_2H_2 equivalents (kg C_2H_2).

b) Toxic Impact Potential Categories

Toxic impact categories include human toxicity and eco toxicity which aggregate all toxic emissions potentially impacting human health and the environment respectively in to m3 soil, air or water (m3). The new impact potential in EASEWASTE, stored toxicity, has been introduced in order to quantify what is left in the waste after the designated time periods for landfills. It is obvious that in landfills, the organic waste many be fully degraded or made inert but the waste still contains significant amount of materials that keep leaching for long time. The model of stored toxicity keeps the account of how much is left of each substance in the waste at the end of each period and ascribes each substance the characterization factor of eco toxicity to water and soil i.e. 50% each. In the long run, half of the toxic substances end up in water compartment and the other half in the soil compartment (Christenesn, Bhander et al. 2007; DTU 2008).

c) Framework of the LCA

i) System Boundaries

For the EASEWASTE operation for the Research, the model has been modified according to the collected data relevant to solid waste management system of Vyas municipality. According to the scenario of Vyas Municipality's waste, the generated gas from the landfill and the collected leach ate for the treatment taken as the default data of Ease waste. It is due to lack of resources. The four time periods depends on the quantity of organic matter and the methane potential of the Landfill site. Hence, the time periods are divided according to the LFG generation of the landfill. And the sorting efficiencies of the waste composition are modified in order not to send all the organic waste into the landfill. The treatment process in this scenario is composting gibing different results from the model.

ii) LCA Evaluation

The two scenarios defined in the model separately are compared using the modified models of the

EASEWASTE. The comparison is conducted by the LCA evaluation in the model resulting in comparison of different environmental impacts, namely, Global warming, Photochemical Ozone formation, Stratospheric Ozone depletion, Nutrient Enrichment, Human toxicity (via soil, water, air) , Eco toxicity (in soil and in water chronic) and Acidification and so on. The concrete figures are resulted in terms of compartments of environmental impacts, which is compared and analyzed.

iii) Calculations

The results for the scenarios were calculated as normalized potential impacts according to the normalized environmental impacts potential reference of LCIA method, EDIP 1997 (Wenzel et al. 1997). Normalization provides a relative expression of the environmental impact or resource consumption compared to the impact from one average person. The yearly contributions from the defined system are divided by the normalization reference, which are the yearly total emission (global/regional/local) per person (worldwide/regionally/locally). This yields a normalized impact potential in the unit "person equivalent", which is abbreviated to PE (Hansen et al. 2006b). In the EASEWASTE software, a positive value of normalized impact potential means a contribution to the impact, and a negative value indicates that the system in the scenario leads to avoidance of the impact or resource consumptions. According to Christensen, Bhander et al. 2007, the potential environmental impacts are:

Table 3: Impact potential categories in EASEWASTE (Christensen, Bhander et al. 2007)

S.N	Impact	Equivalences	Physical basis
1	Global Warming	kg CO2-eq	Global
2	Eco toxicity in Water, Chronic	m3 water	Regional
3	Stored Eco toxicity in Water	m3	Regional
4	Human Toxicity via Soil	m3	Regional
5	Resource depletion	kg	Global
6	Spoiled Groundwater Resources	m3	Local
7	Eco toxicity in Soil	m3	Regional
8	Human Toxicity via Water	m3	Regional
9	Acidification	kg SO2-eq	Regional
10	Stratospheric Ozone Depletion	kg CFC11-eq	Global
11	Human Toxicity via Air	m3	Regional
12	Stored Eco toxicity in Soil	m3	Regional
13	Nutrient Enrichment	kg NO3-eq	Regional
14	Photochemical Ozone Formation	kg C2H4-eq	Regional

5. LCA Evaluation of Vyas Municipal Waste with Different Scenarios

Figure 5 below illustrate the environmental impacts caused by scenario 1. It can be seen that the highest impacts during 100 year period are on Human toxicity and Eco-toxicity in water. The major contribution (direct impact) is due to direct disposal of waste in river bank. The total quantity toxic emitted that caused human toxicity is 1,072,469,260.192(m^3) per year with reference to EDIP97.

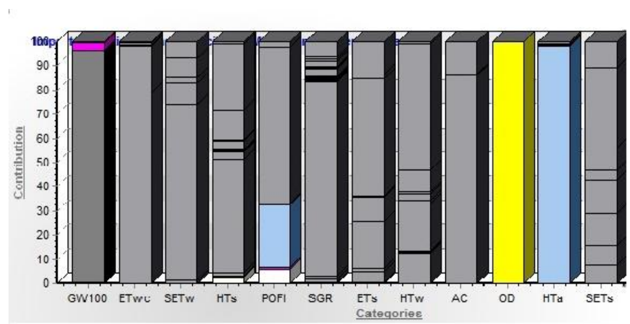

Figure 5: Environmental Impact potential of scenario 1

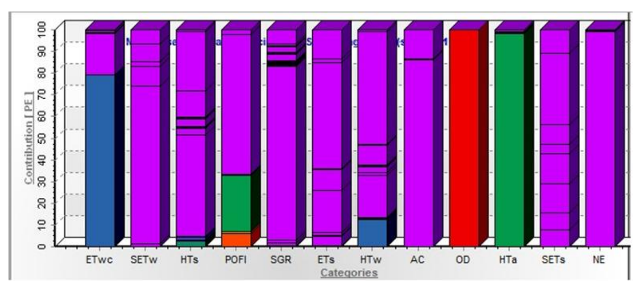

Figure 6: Normalized potential impacts for scenario 1

Similarly global Warming -2,790.93 kgCO2-eq,Eco toxicity in Water, Chronic 39,799.47 m3 water, Stored Eco toxicity in Water 480,056.14 m3,Human Toxicity via Soil 0.214 m3,Photochemical Ozone Formation, Low NOx 0.181 kg C2H4-eq,Spoiled Groundwater Resources 64,574.53 m3,Eco toxicity in Soil 0.84 m3,Human Toxicity via Water 67.276 m3, Acidification 0.991 kg SO2-eq,Stratospheric Ozone Depletion 0 kg CFC11-eq, Stored Eco toxicity in Soil 5.196 m3,Nutrient Enrichment 1.662 kg NO3-eq and Photochemical Ozone Formation, High NOx 0.189 kg C2H4-eq.

Table 4: Environmental impact potential of the scenario 1 with various module styles

	module name		
Impact	**residual waste**	**landfill mixed waste**	**Madi river side landfill**
Weighing			
Global Warming	0.0062	0.0006	-0.3661
Eco toxicity in Water, Chronic	0.0497	0.0051	0.0786
Stored Eco toxicity in Water	0	0	0
Human Toxicity via Soil	0.0007	0.0001	0.0013
Photochemical Ozone Formation, Low NOx	0.0032	0.0003	0.0061
Spoiled Groundwater Resources	0	0	0
Eco toxicity in Soil	0	0	0
Human Toxicity via Water	0.0004	0	0.0013
Acidification	0.0056	0.0006	0.0109
Stratospheric Ozone Depletion	0	0	0.0025
Human Toxicity via Air	0.0067	0.0007	0.0172
Stored Eco toxicity in Soil	0	0	0
Nutrient Enrichment	0.0058	0.0006	0.0107
Photochemical Ozone Formation, High NOx	0.0034	0.0003	0.0064
Impact potentials			
Global Warming	-0.0173	-0.0018	1.019
Eco toxicity in Water, Chronic	0.3727	0.038	0.5893
Stored Eco toxicity in Water	0	0	1
Human Toxicity via Soil	0.3345	0.0341	0.6314
Photochemical Ozone Formation, Low NOx	0.3355	0.0342	0.6303
Spoiled Groundwater Resources	0	0	1
Eco toxicity in Soil	0.084	0.0086	0.9075
Human Toxicity via Water	0.248	0.0253	0.7267
Acidification	0.3275	0.0334	0.6392
Stratospheric Ozone Depletion	0	0	1
Human Toxicity via Air	0.2734	0.0279	0.6988
Stored Eco toxicity in Soil	0	0	1
Nutrient Enrichment	0.3396	0.0346	0.6258
Photochemical Ozone Formation, High NOx	0.3334	0.034	0.6326
Normalization			
Global Warming	0.0055	0.0006	-0.3269
Eco toxicity in Water, Chronic	0.0421	0.0043	0.0666
Stored Eco toxicity in Water	0	0	0.0421
Human Toxicity via Soil	0.0006	0.0001	0.0011
Photochemical Ozone Formation, Low NOx	0.0024	0.0002	0.0046
Spoiled Groundwater Resources	0	0	461.2466
Eco toxicity in Soil	0	0	0
Human Toxicity via Water	0.0003	0	0.001
Acidification	0.0044	0.0004	0.0086
Stratospheric Ozone Depletion	0	0	0
Human Toxicity via Air	0.0048	0.0005	0.0123
Stored Eco toxicity in Soil	0	0	0.0103
Nutrient Enrichment	0.0047	0.0005	0.0087
Photochemical Ozone Formation, High NOx	0.0025	0.0003	0.0048

The figure 14 shows the environmental impacts caused by scenario 2 that has more or less similar trend of the impacts as of scenario 1. The highest impacts in this scenario are on the on Human toxicity and Eco-toxicity in water. The total quantity toxic emitted that caused human toxicity is, 411,548,307.452m^3 per year with reference to EDIP97. Similarly global Warming-1,377.26kg CO2-eq,Eco toxicity in Water, Chronic 14,143.20m3 water, Stored Eco toxicity in Water 0m3,Human Toxicity via Soil-2.218m3,Photochemical Ozone Formation, Low NOx -0.17kg C2H4-eq，Spoiled Groundwater Resources 0m3,Eco toxicity in Soil -40.068m3,Human Toxicity via Water-1,781.62m3.Acidification -2.094kg SO2-eq,Stratospheric Ozone Depletion 0kg CFC11-eq,Stored Eco toxicity in Soil 0m3,Nutrient Enrichment -1.252kg NO3-eq,Photochemical Ozone Formation, High NOx -0.166kg C2H4-eq. Waste recycling and composting are the major contributor's emissions Acidification and Nutrient Enrichment. Negative value of acidification and nutrient enrichment have saved great amount of impact on Human toxicity and Eco- toxicity.

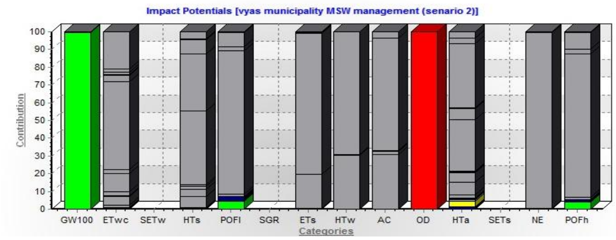

Figure 7: Environment impact potential of scenario 2

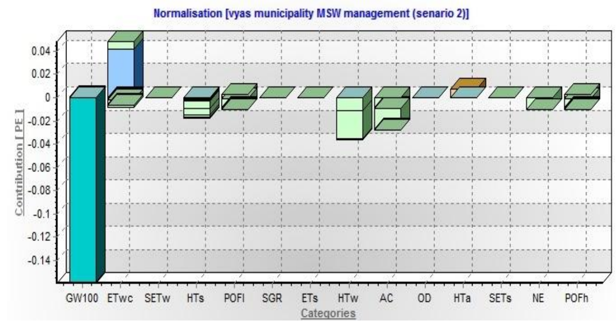

Figure 8 Normalized potential impacts for scenario 2

Table 5: Environmental impact potential of the scenario 2 with various module styles

Impact	Module name		
	Residual waste	**Landfill mixed waste**	**Anaerobic digestion**
Weighing			
Global Warming	0.0062	0.0007	-0.1842
Eco toxicity in Water, Chronic	0.0497	0.0057	-0.008
Stored Eco toxicity in Water	0	0	0
Human Toxicity via Soil	0.0007	0.0001	-0.0223
Photochemical Ozone Formation, Low NOx	0.0032	0.0004	-0.0127
Spoiled Groundwater Resources	0	0	0
Eco toxicity in Soil	0	0	0
Human Toxicity via Water	0.0004	0	-0.0468
Acidification	0.0056	0.0006	-0.0421
Stratospheric Ozone Depletion	0	0	-0.0006
Human Toxicity via Air	0.0067	0.0008	0.0019
Stored Eco toxicity in Soil	0	0	0
Nutrient Enrichment	0.0058	0.0007	-0.0193
Photochemical Ozone Formation, High NOx	0.0034	0.0004	-0.0126
Normalization			
Global Warming	0.0055	0.0006	-0.1645
Eco toxicity in Water, Chronic	0.0421	0.0048	-0.0068
Stored Eco toxicity in Water	0	0	0
Human Toxicity via Soil	0.0006	0.0001	-0.0181
Photochemical Ozone Formation, Low NOx	0.0024	0.0003	-0.0095
Spoiled Groundwater Resources	0	0	0
Eco toxicity in Soil	0	0	0

Human Toxicity via Water	0.0003	0	-0.036
Acidification	0.0044	0.0005	-0.0332
Stratospheric Ozone Depletion	0	0	0
Human Toxicity via Air	0.0048	0.0006	0.0014
Stored Eco toxicity in Soil	0	0	0
Nutrient Enrichment	0.0047	0.0005	-0.0158
Photochemical Ozone Formation, High NOx	0.0025	0.0003	-0.0094
Impacts			
Global Warming	48.1894	5.5249	-1,430.97
Eco toxicity in Water, Chronic	14,833.69	1,700.68	-2,391.17
Stored Eco toxicity in Water	0	0	0
Human Toxicity via Soil	0.0716	0.0082	-2.2975
Photochemical Ozone Formation, Low NOx	0.0609	0.007	-0.238
Spoiled Groundwater Resources	0	0	0
Eco toxicity in Soil	0.0705	0.0081	-40.1468
Human Toxicity via Water	16.6856	1.913	-1,800.22
Acidification	0.3246	0.0372	-2.4554
Stratospheric Ozone Depletion	0	0	0
Human Toxicity via Air	293,187,126.13	33,613,810.64	84,747,370.69
Stored Eco toxicity in Soil	0	0	0
Nutrient Enrichment	0.5644	0.0647	-1.8808
Photochemical Ozone Formation, High NOx	0.063	0.0072	-0.2361

Figure 8 shows normalized potential impacts caused by scenario 2, the scenario where all the organic contents of the city is assumed sending for composting instead of land filling. In Accordance to the life cycle perspective, this is the best scenario where all the impacts are very low compared to the first scenarios except global warming. The impact on Nutrient enrichment is high due to high quantity of Ammonia (NH3) and Phosphate (PO4) discharged from composting. The nutrient enrichment because of composting is demonstrated to be very high due to the huge amount of production of Ammonia (NH3) and Phosphates that increases the nutrients of the soil. The impact on photochemical ozone formation is significantly reduced because methane is the sole largest contributor to the photochemical ozone formation (POf). 80% of impact on POf is due to methane coming out of landfill. Hence absence of organic matter in the landfill saved great deal of impact of POf. The table below gives the modules comparisons with reference of the scenario 2. From the table the negative value of the anaerobic digestion style demonstrated the best over the modules.

Table 6Comparisons of Scenario 1 and Scenario 2

Impacts	Diff (PE)	Remarks
Global Warming	0.163	scenario1 is slightly better than scenario 2
Eco toxicity in Water, Chronic	-0.073	scenario 2 is better than scenario1
Stored Eco toxicity in Water	-0.042	scenario 2 is better than scenario1
Human Toxicity via Soil	-0.019	scenario 2 is better than scenario1
Photochemical Ozone Formation, Low NOx	-0.014	scenario 2 is better than scenario1
Spoiled Groundwater Resources	-461.247	scenario 2 is better than scenario1
Eco toxicity in Soil	0	indifference
Human Toxicity via Water	-0.037	scenario 2 is better than scenario1

Acidification	-0.041	scenario 2 is better than scenario1
Stratospheric Ozone Depletion	0	indifference
Human Toxicity via Air	-0.011	scenario 2 is better than scenario1
Stored Eco toxicity in Soil	-0.01	scenario 2 is better than scenario1
Nutrient Enrichment	-0.025	scenario 2 is better than scenario1
Photochemical Ozone Formation, High NOx	-0.015	scenario 2 is better than scenario1

It shows the comparison of the impacts on human and environment from scenario 1 and scenerio2. From the above tables, it is understood that the sored eco-toxicity is very high for the scenario 1 that can have negative impacts in human health. According to the LCIA, the soil is to be contaminated by the heavy metals like Chromium (Cr), Lead (Ld), Mercury (Hg), Arsenic (As) and Cadmium (Cd) discharged by the scenarios. The difference in PE between scenario 1 and scenario 2 gives the comparatively best option. The table13 below illustrate that photochemical ozone formation, acidification, nutrient enrichment, stored Eco toxicity in water and other impacts of scenario 2 is far better than scenario 1.

6. Discussion

Waste management is complex issue addressing all the three aspects of sustainability i.e. economic, social and environment. Waste generation is increased in Vyas municipality with urbanization and consumption pattern. Though prevention of waste is the key element in any management system, proper integrated waste management leads to an improved quality of waste with reduced economic impact and improved resource utilization. The results from the environmental assessment of the solid waste system in the Vyas municipality showed the composting the organic waste generation is better than the current system, mainly due to the lowering of stored Eco-toxicity.

The organic content of the Vyas municipality waste is very high. There were significant improvements in most of the potential environmental impacts composting the organic waste generated from the Vyas municipality. The total amount of Organic waste generated from the municipality is 66% of total solid waste. Composting this amount of Organic waste makes a great contribution to reducing green-house gas storing large amount of carbon in the soil. Moreover, it is also advantageous that the number of vehicles and amount of fuel combusted during transporting these wastes is saved in huge amount diminishing the large quantity of pollutants like NOx, SOx, CO, from the vehicles.

Software EASEWASTE provided a systematic and holistic method to evaluate the environmental impacts and benefits from solid waste systems. It not only presented the best alternatives but provided all the resources and pollutants that are responsible for the environmental impacts. This Life cycle understanding will assist scientifically for waste management optimization, especially for the investigation and development of a strategy for waste management in Vyas municipality. Economic costs, odor, dust, noise, ethical issues and social willingness towards a waste management system are other concerns to consider while choosing or optimizing a solid waste management system.

Two scenarios have been demonstrated and analyzed by considering an integrated system of collection, transportation, treatment, recovery and disposal of total generated solid waste(9.87 tons per day). A comprehensive conclusion has been made by focusing on the processes that had significant impact on impact potentials and major substances contributing to environmental loads as input or emissions from processes or technologies throughout the integrated management system.The total quantity toxic emitted that caused human toxicity is, 1,072,469,260.192(m3) per year with reference to EDIP97. On the top of that the various impact of the scenario 1 are-2,790.93 (GW),0.181(NOx),0.991(AC),1.662(NE) and so on. Similarly the highest impacts in this scenario 2 are on the on Human toxicity and Eco-toxicity in water. The total quantity toxic emitted that caused human toxicity is, 411,548,307.452m^3. -1,377.26(GW),Human Toxicity via Water-1,781.62m3.Acidification -2.094kg SO2-eq,-1.252(NE), Waste recycling and composting are the major contributor's emissions Acidification and Nutrient Enrichment. Negative value of acidification and nutrient enrichment have saved great amount of impact on Human toxicity and Eco- toxicity.

Most of the recycling technologies result negative normalized impacts for global warming impact and acidification mainly from organic waste, paper, plastics metal and glass. The anaerobic disgusting avoids the impacts to resource depletion. Global Warming 0.163,Eco toxicity in Water, Chronic -0.073,Stored Eco toxicity in Water -0.042,Human Toxicity via Soil -0.019,Photochemical Ozone Formation, Low NOx -0.014,Spoiled Groundwater Resources -461.247,Human Toxicity via Water -0.037,Acidification -0.041,Nutrient Enrichment-0.025,Photochemical Ozone Formation, High NOx-0.015.

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