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Quantitative and Qualitative Study of MSW from Papumpare District in Arunachal Pradesh

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Abstract—More than 29 million tons of municipal solid waste (MSW) is produced every year in India [1]. It is due to the concentration of very high population in urban areas and added new types of wastes from shops, institutes and factories. Due to high amount of organic materials, MSW has high energy content. The energy content of the MSW collected from NERIST campus is found to be 19556kJ/kg of dry MSW. Most of the solid wastes are disposed of by land filling in low-laying areas located in and around the urban centers. The landfill gas generated from the MSW is entered into the atmosphere which may be one of the reasons of global warming. Most of the constituents of MSW landfill gas are methane and carbon dioxide [2] which are premier green house gases (GHG). Methane emission from landfill is estimated to account for 3-19 % of the anthropogenic sources in the world [3]. But if the gas can be used scientifically, it can generate a large amount of energy, since it has approximately one-half the calorific value than that of natural gas. Landfill gas can often be used in place of conventional fossil fuels in certain applications. It is a reliable source of energy because it is generated 24 hours a day, 7 days a week. By using landfill gas to produce energy, landfills can significantly reduce their emissions of methane and avoid the need to generate energy from fossil fuels, thus reducing emissions of carbon dioxide, sulfur dioxide, nitrogen oxides, and other pollutants from fossil fuel combustion. The main objective of present work is the quantitative and qualitative study of MSW from Papumpare district in Arunachal Pradesh for proper MSW management.

Keywords—Municipal Solid Waste, Organic Content, Moisture Content, Energy Content,

I. INTRODUCTION

With the rapid growth of population, there has been a substantial increase in the generation of solid waste resulting into the contamination of air, water and land resources. Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of that pose risks to the environment and to public health. Municipal solid wastes, commonly known as trash or garbage, are the solid wastes generated from different municipalities. Some of these wastes have been proved to be extremely toxic and infectious. The uncontrolled and unscientific dumping of such wastes has brought about a rising number of incidents of hazards to human health. More serious risk to human health is envisaged due to contamination of surface and ground water. Beside this gases like CH_4 and CO_2 are greenhouse gases which contribute to rise in global temperature. The indiscriminate dumping of municipal solid wastes in water bodies and low lying areas is a common practice followed by most of the municipalities with no consideration of its effect on the environment.Municipal solid waste (MSW) is an integral part of any society. As a result of human activities, wastes are generated and accumulated. Unless proper solid waste management plans are applied, serious environmental problems may be produced, such as those associated with air, water and land pollution. The most traditional and popular disposal practice for MSW is landfilling [4].Because of the limited land availability in some countries and some environmental problem associated with the landfilling process, such as gas emission and leachate production, the technology of landfilling needs to be improved[2]. There are potential risks to environment and health from improper handling of solid wastes. Direct health risks concern mainly the workers in this field, who need to be protected, as far as possible, from contact with wastes. There are also specific risks in handling wastes from hospitals and clinics. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats.

The most obvious environmental damage caused by municipal solid wastes is aesthetic, the ugliness of street litter and degradation of the urban environment and beauty of the city. More serious, however, and often

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unrecognised, is the transfer of pollution to water, ground water. Air pollution can be caused from the inefficient burning of wastes, either in open air, or in plants that lack effective treatment facilities from the gaseous effluents. Uncontrolled hazardous wastes from industries mixing up with municipal wastes create potential risks to human health

This paper aims (i)to determine the yearly municipal solid waste generated from Papumpare district of Arunachal Pradesh by segregating municipal solid waste at disposal site, and(ii)to calculate chemical composition of MSW from various sources of Papumpare district of Arunachal Pradesh.

II. Municipal Solid Waste

Municipal solid waste (MSW), also called urban solid waste, is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. MSWincludes the waste product collected as garbage, rubbish, ashes, construction and demolition wastes, and dead animals, etc.

A. Sources and composition of MSW

The different sources and composition of MSW is shown in Table 1.

TABLE 1SOURCES AND COMPOSITION OF MSW

Kind	Composition	Sources
Garbage	Kitchen waste:(Waste from preparation, cooking and serving food) Market wastes:(wastes from handling, storage and sale of products)	Household, restaurants, institution, stores, market
Rubbish	Combustible: paper, cartons, boxes, barrels, wood, tree branches, wood furniture, bedding. Non-combustible: metals, tin cans, metal furniture's, dirt, glass, crockery, minerals.	Households,restaurants, institutions,stores, markets
Ashes	Residues from fires used for cooking and heating and on-site incineration	Do
Demolition wastes	Lumber,pipes,bricks,masonry and other construction materials from razed buildings and other structures	Do
Dead animals	Cats, dogs, cows, horses	Do

B. MSW components and their energy content

Table 2 shows different constituent of MSW and their respective energy content. The total energy content of the MSW can be calculated by knowing the weights and moisture content of each constituent. It shows that the MSW has high value of energy content. To extract the energy while disposing of the wastes in proper, eco-friendly and planned way is the main concern of solid waste management.

TABLE 2 MSW components and their energy content[2]

Component of MSW	Energy content (kJ/kg)
Organic	
Food wastes	4652
Paper/cardboard	16747.2
Plastics	32564
Textiles	17445
Leather	17445
Wood	18608
Inorganic	
Glass	139.56
Tin cans	697.8
Ferrous metal	697.8
Other metal	697.8
Dirt, ashes, bricks	6978

C. MSW Characteristics and Composition in India

The composition and the quantity of MSW generated form the basis on which the management system needs to be planned, designed and operated. In India, MSW differs greatly with regard to the composition and hazardous nature, when compared to MSW in the western countries [8]. The composition of MSW at generation sources and collection points determined on a wet weight basic consists mainly of a large organic fraction (40-60%), ash and fine earth (30-40%), paper (3-6%) and plastic, glass and metals (each less than 1%). The C/N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg.

D. Storage and Collection of MSW

Storage of MSW at the source is substantially lacking in most of the urban areas. The bins are common for both decomposable and non-decomposable waste (no segregation of waste is performed), and the waste is disposed at a communal disposal centre. Storage bins can be classified as movable bins and fixed bins. The movable bins are flexible in transportation but lacking in durability while the fixed bins are more durable but their positions cannot be changed once they have been constructed [5].

The average collection efficiency for MSW in Indian cities and states is about 70%, as shown in Table 3 [6]. Itshows that the collection efficiency is high in the cities

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and states, where private contractors and NGOs are employed for the collection and transportation of MSW. Most of the cities are unable to provide waste collection services to all parts of the city. The Central Pollution Control Board (CPCB) has collected data for the 299 Class-I cities to determine the mode of collection of MSW. It is found that manual collection comprises 50%, while collection using trucks comprises only 49% [7].

TABLE 3 PER CAPITA GENERATION, DISPOSAL AND COLLECTION EFFICIENCY OF MSW FOR INDIAN STATE [6]

State	Per capita generation (g/cap/day)	Per capita disposal (g/cap/day)	Collection Efficiency (%)
Andhra Pradesh	346	247	74
Bihar	411	242	59
Guajrat	297	182	61
Haryana	326	268	82
Karnataka	292	234	80
Kerala	246	201	82
Madhya Pradesh	229	167	73
Maharashtra	450	322	72
Orissa	301	184	61
Punjab	502	354	71
Rajasthan	516	322	62
Tamil Nadu	294	216	73
Uttar Pradesh	439	341	78
West Bengal	158	117	74
Indian (Sample Average)	377	273	72

E. Transfer and transport of MSW

Transfer station (except in a few cases as in Madras, Mumbai, Delhi, Ahmedabad and Calcutta) are not used, and the same vehicle, which collects refuse from individual dustbins, takes it to the processing or disposal site. The MSW collected from the dustbins and collection points is transported to the processing or disposal sites using a variety of vehicles in smaller (rural) towns bullock carts, tractor-trailers tricycles etc. are mainly used for the transportation of MSW. Light vehicles andlorries are generally used in big towns or cities for transport of MSW. The trucks used for transportation of MSW are generally of an open body type and are usually kept uncovered; thus during transportation the waste tends to spill onto the road resulting in unhygienic conditions. In some cities modern hydraulic vehicles are gradually being introduced.

Collection and transportation activities constitute approximately 80-95% of the budget of MSWM, hence, it forms a key component in determining the economics of MSWM system. Municipal agencies use their own vehicles tor MSW transportation although in some cities they are hired from private contractors [6].

F. Effect of improper disposal of MSW to environment and health

The group at risk from the unscientific disposal of solid waste include the population in areas where there is no proper waste disposal method, especially pre-school children, waste workers, and workers in facilities producing toxic and infectious material. Other high risk groups include population living close to a waste dump and those whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury, and infection. Epidemiological studies have shown that a high percentage of workers who handle refuse, and of individuals who live near or on disposal sites, are infected with gastrointestinal parasites, worms and related organisms. Contamination of this kind is likely at all points where waste is handled. Although it is known that vector insects and rodents can transmit various pathogenic agents (amoebic and bacillary dysentery, typhoid fever, salmonellosis, various parasites, cholera, yellow fever, plague and others), it is often difficult to trace the effects of such transmission to a specific population. During the last decade of the 19th century as well as during the 5 initial years of 20th century, millions of people died due to Bubonic Plague in India, which had linkages to poor management of Solid Waste. More recently a study by the US Public Health Service has demonstrated the relationship of 22 human diseases to improper solid waste management. The organic fraction of Municipal Solid Waste is an important component,not only because it constitutes a sizable fraction of the solid waste stream, but also because of its potentially adverse impact upon public health and environmental quality. A major adverse impact is due to its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odours, unsightliness, land, water, air and noise pollution.These impacts are not confined merely to the disposal site. On the contrary, they pervade the area surrounding the site and wherever the wastes are generated, spread or accumulated. Unless an organic waste is appropriately managed, its adverse impact will continue until it has fully

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decomposed or otherwise stabilized. Uncontrolled or poorly managed intermediate decomposition products can contaminate air, water and soil resources. Most development activities are expected to have a beneficial effect on human health by increasing the resources available for food, education, employment, water supply, sanitation and health services. Proper management of municipal solid waste should have minimum effects on environment and health

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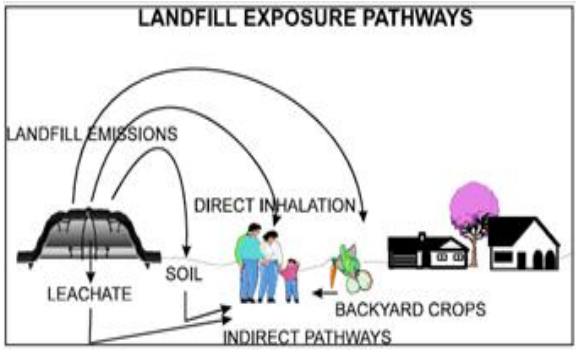

Fig.1Effect of landfill disposal of MSW

G. MSW Disposals and Treatment

The two leading innovative mechanisms of waste disposal being adopted in India include composting (aerobic composting and vermi-composting) and waste-to-energy (WTE) (incineration,pelletisation,biomethanation). WTE projects for disposal of MSW a relatively new concept in India. Although these have been tried and tested in Developed countries with positive results these are yet to get off the ground in India largely because of the fact that financial viability and sustainability is still being tested. Different methods tor the disposal and treatment of MSW have been discussed in the subsequent sections.

H. Recycling of Organic Waste

If the organic waste is left unattended, it will tend to decompose by natural process giving rise to odours, hosting and feeding a variety of insects and pests, which in turn fond the carriers of disease creating severe health problems. The segregation decomposition and stabilization of the organic waste by biological action forms the basis of recycling through different natural cycles.

III. EXPERIMENTATION

A. Field work (Quantitative Measurement)

The quantity of MSW was determined by segregating MSW at disposal site and measuring each constituent separately, like paper, plastics, food waste, leather etc. The weight was measured with the help of handy pocket balance. After finding out the weight of each fraction, total weight of MSW per truck or tractor trolley has been calculated. Considering the numbers of trips made by vehicle, MSW production per day/year has been calculated.

(i) Quantitative measurement of MSW from NERIST

TABLE 4 WEIGHT OF DIFFERENT CONSTITUENTS PER TRACTOR TROLLEY OF MSW FROM NERIST

S. No.	Constituent	Weight (kg)
1.	food	777.8336
2.	paper/cardboard	74.9732
3.	plastics	196.9828
4.	textiles	48.6500
5.	wood	5.0000
6.	glass	20.7396
7.	tin cans	11.6520
8.	ferrous metal	0.0000
9.	other metal	4.0000
10.	dirt, ashes bricks	4.0000
11.	leather	27.7396
	Total	1171.5708

Total weight of MSW per tractor trailer from NERIST
=1171.5708kg
No.of trips per week=3
Weight of MSW per week
=3x1171.5708 kg =3514.7124kg
No. of trips per month=12
Weight of solid waste per month=14058.8496kg
No. of trips per year=3 x 4 x 12 = 144
Weight of solid waste per year
= 1171.5708 x 144 =168706.1952kg
=168.7061952tonne

(ii) Quantitative measurement of MSW from Itanagar

Three trucks (say no. 1, 2 and 3) are engaged in transportation of MSW. Truck 1 and Truck 2 are of same specification. Each truck make two trips daily, six days per week (Monday to Saturday). Capacity (volume) of Truck 1 and Truck 2 was calculated to be 7.8645m^3, whereas the capacity of Truck 3 was 6.0025m^3.

TABLE 5 WEIGHT OF DIFFERENT CONSTITUENTS PER TRUCK OF MSW FROM ITANAGAR (Truck 1)

S. No.	Constituent	Weight (kg)
1.	food	1841.9312
2.	paper/cardboard	63.7840
3.	plastics	240.6980
4.	textiles	43.4792

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5.	wood	2.9132
6.	glass	24.9132
7.	tin cans	6.8267
8.	non ferrous metal	0.9132
9.	dirt, ashes bricks	5.0000
10.	leather	18.7396
	Total	2,249.1983

Weight of MSW per Truck 1 =2,249.1983kg
=2.2491983tonne
Weight of MSW per Truck 2 = 2,249.1983 kg
=2.2491983 tonne
Weight of MSW per Truck 3 = 2,178.30 kg
= 2.1783 tonne
No. of trips per Truck per day = 2 times.
No. of trips per Truck per week
= 2 x 6 = 12 (excluding Sunday)
From the above mentioned values, quantity of solid waste production per year from Itanagar has been calculated to be 3845777.242 kg/year
=3845.777242 tonne/year

(iii) Quantitative measurement of MSW from Naharlagun

There were four Trucks (say no. A, B, C and D). The Trucks B, C and D were of same capacity.

The constituents of each fraction presents in municipal solid waste of Naharlagunfrom Truck A was calculated by segregation and tabulated in Table 6.

TABLE 6 WEIGHT OF DIFFERENT CONSTITUENTS PER TRUCK OF MSW FROM NAHARLAGUN (Truck A)

S. No.	Constituent	Weight (kg)
1.	food	1758.9312
2.	paper/cardboard	53.7840
3.	plastics	230.6980
4.	textiles	50.4792
5.	wood	1.9132
6.	glass	30.9132
7.	tin cans	7.8260
8.	non ferrous metal	0.0000
9.	dirt, ashes bricks	2.0000
10.	leather	20.7396
	Total	2,157.2844

TABLE 7 WEIGHT OF DIFFERENT CONSTITUENTS PER TRUCK OF MSW FROM NAHARLAGUN (Truck B/C/D)

S. No.	Constituent	Weight (kg)
1.	food	1658.0000
2.	paper/cardboard	64.4000
3.	plastics	170.0000
4.	textiles	40.0000
5.	wood	2.856.0000
6.	glass	20.9704
7.	tin cans	30.8267
8.	non ferrous metal	0.0000
9.	dirt, ashes bricks	2.0000
10.	leather	17.7396
	Total	2006.7927

Weight of MSW per Truck A = 2,157.2844 kg
=2.1572844tonne
Weight of MSW per truck B/C/D = 2006.7927 kg
=2.0067927 tonne
No. of truck = 4.
No. of trips per Truck per day = 2 times.
No. of trips per Truck per week
= 2 x 6 = 12 (excluding Sunday)
From the above mentioned values, quantity of solid waste production per year from Itanagar has been calculated to be 4,710,333.599 kg/year
=4,710.334 tonne/year

(iv) Quantitative measurement of MSW from Banderdewa/Yupia/Doimukh/Nirjuli

The constituents of each fraction presents in municipal solid waste of Banderdewa/Yupia/Nirjuli/Doimukh are calculated by segregation, after segregation weight of each fraction is measured by using handy pocket balance.

TABLE 8WEIGHT OF DIFFERENT CONSTITUENTS PER TRUCK OF MSW FROM BANDERDEWA/YUPIA/DOIMUKH/NIRJULI

S. No.	Constituent	Weight (kg)
1.	food	1500.0000
2.	paper/cardboard	70.4000
3.	plastics	130.0000
4.	textiles	50.0000
5.	wood	4.9132
6.	glass	34.9132
7.	tin cans	5.8267
8.	non ferrous metal	0.0000
9.	dirt, ashes bricks	3.0000
10.	leather	25.7396
	Total	1824.7927

Total weight of MSW per truck=1824.7927 kg
=1.8247927 Tonne.
No. of truck=1
Volume of a truck = 6.0025m^3
No.of trips per day=2times
No. of trips per Truck per week
=2 x 6 = 12 (excluding Sunday)

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Hence, the quantity of MSW production per year from Banderdewa/Yupia/Nirjuli/Doimukhhas been calculated to be 1,051,080.595 kg/year

= 1,051.080595 ton/year

(v) Total Quantity of MSW generated in Papumpare district of Arunachal Pradesh

Table 9Represents the total quantities of Municipal solid waste production in Papumpare district, various sources of MSW in Papunpare district, transportation facilities, mode of transport and disposal site in papumpare district.

TABLE 9 TOTAL QUANTITY OF MSW GENERATED IN PAPUMPARE DISTRICT

Sources of MSW	Mode of transport	Disposal site	MSW Production per year (tonne)
Itanagar	By Truck	Chimpu	3,845.7774
Naharlagun	By Truck	Chimpu	4,710.3336
NERIST Campus	By Tractor Trailer	Chimpu	168.7062
Doimukh/ Banderdewa/ Yupia/ Nirjuli	By Truck	Chimpu	1,051.0806
Total			9,775.8978 9,690.392649

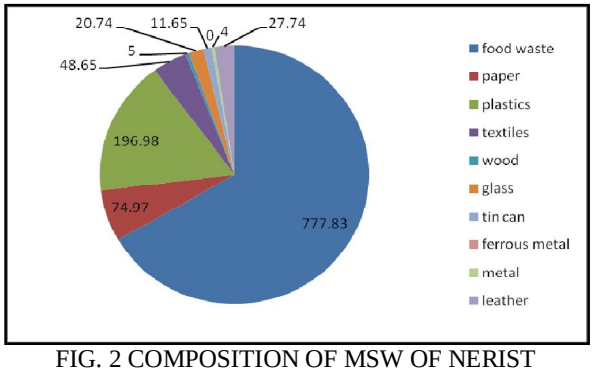

FIG. 2 COMPOSITION OF MSW OF NERIST CAMPUS

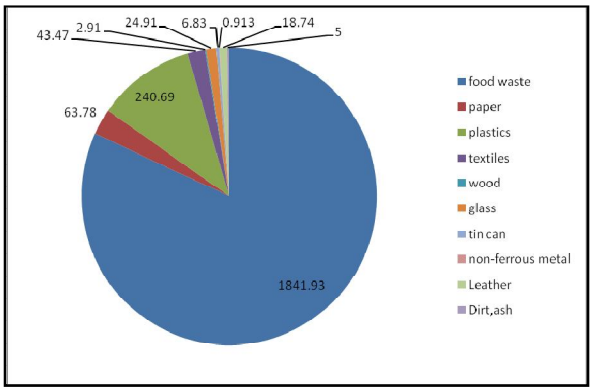

FIG. 3 COMPOSITION OF MSW OF ITANAGAR

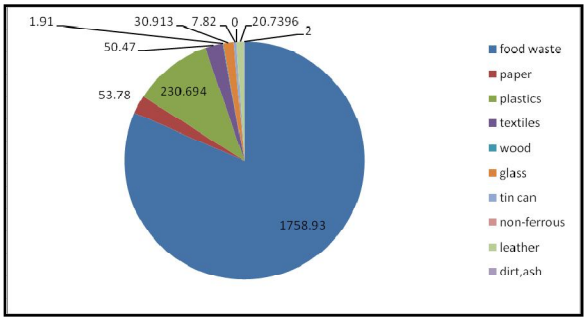

FIG. 4COMPOSITION OF MSW OF NAHARLAGUN

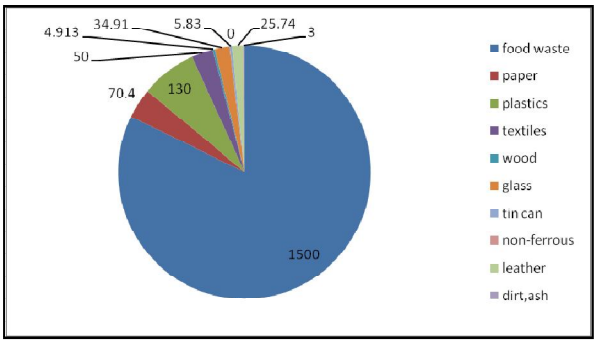

FIG. 5 COMPOSITION OF MSW OF BANDERDEWA/NIRJULI/ DOIMUKH/YUPIA.

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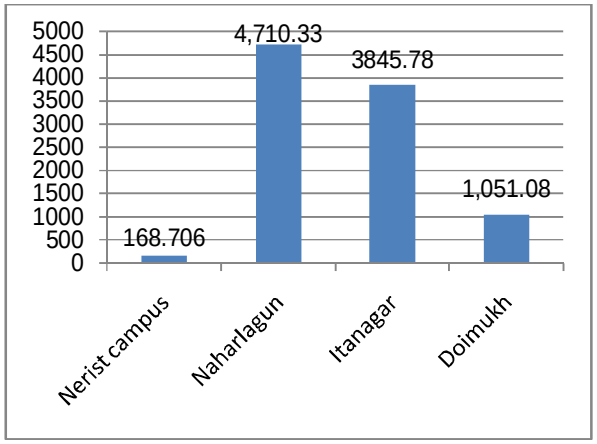

FIG. 6 MSW OF PAPUMPARE DISTRICT IN TONNE/YEAR

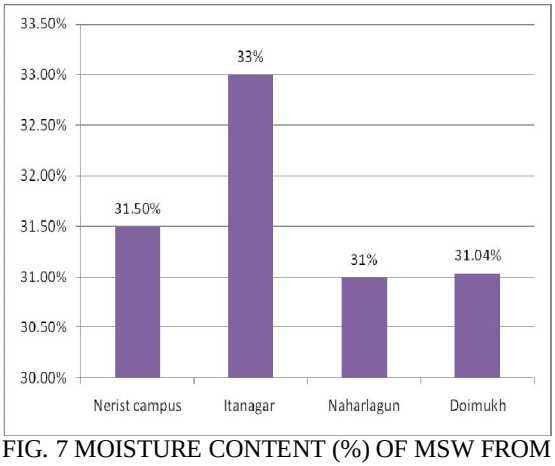

FIG. 7 MOISTURE CONTENT (%) OF MSW FROM VARIOUS SOURCES

B. Laboratory works (Qualitative Measurement)

MSW from different places were tested in the Env. Engg.Lab. of Civil Engg.Dept., NERIST, for Moisture Content (MC) and Organic Content (OC). MC was determined by keeping the MSW sample in the muffle furnace for drying at 103 ^{0}C. OC was determined by igniting the dry MSW at 550 ^{0}C

TABLE 9 MOISTURE CONTENT & ORGANIC CONTENT OF MSW FROM VARIOUS SOURCES

Sources of MSW	MC (%)	OC (%)	
		Wet MSW	Dry MSW
Itanagar	33	71.30	82
Naharlagun	31	71.79	78.91
NERIST	31.5	70.41	74.96
Doimukh/ Banderdewa/ Yupia/ Nirjuli	31.04	72.83	83.21

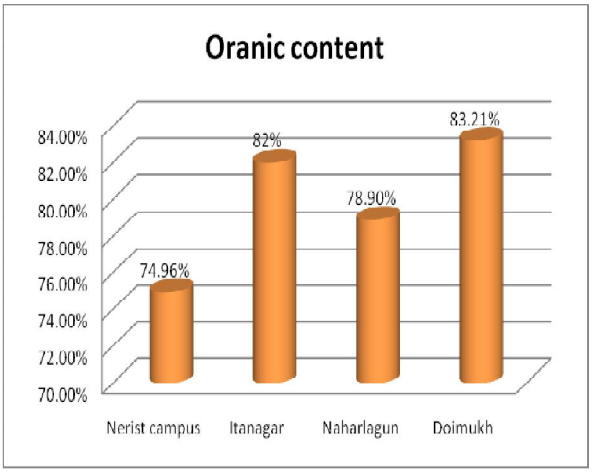

FIG. 8 ORGANIC CONTENT (%) OF DRY MSW FROM VARIOUS SOURCES

C. Estimation of the chemical composition of MSW

TABLE 10 CHEMICAL COMPOSITION OF MSW FROM VARIOUS SOURCES

Sources of MSW	Chemical Composition
Itanagar	
Naharlagun	
NERIST	
Doimukh/ Banderdewa/ Yupia/ Nirjuli	

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IV. CONCLUSION

- Total quantities of MSW generated per Year in Papumpare districtof Arunachal Pradesh is 9,690.393tonne.
- Methane and Carbon dioxide gases are the main end products of the decomposition of solid waste.
- Urban Department of Arunachal Pradesh is still using the obsolete, unscientific open dumping method.
- It is found that concentration of plastic is still more beside ban on use of plastic items.
- If MSW is managed in planned and scientific way it can reduce nuisance to health of people in Papumpare district of Arunachal Pradesh.
- If we able to used energy content in MSW it can be used as substitute of fossil fuels, beside reduction in environmental pollution.
- MSW used as sources of heat and electricity.

Recommendation:

- The Municipalities use less number of Vehicles for collection of Solid wastes than the required number.
- Disposal of solid wastes from Itanagar at Chimpu is suitable but it is not suitable for Nahargun to Chimpu because of the distance factor while transporting, it cause pollution especially at the twin cities, Itanagar and Naharlagun.
- For Naharlagun, Doimukh, Banderdewa and Nirjuli, there should be a separate disposal site.
- It is found that the concentration of plastic is still high beside band on use of polythene bags and plastic items. Scientific and Planned way of solid waste management is necessary in Papumpare District.

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TABLE 10: COMPONENTS AND ENERGY CONTENTS OF EACH CONSTITUENTS OF MSW COLLECTED FROM NERIST CAMPUS

MSW Components	Wet Weight (kg)	Moisture Content (%)	Dry Weight (kg)	Energy Content (kJ/kg)	Total Energy (kJ)
Organic					
Food wastes	777.8336	74.0	202.236	4652.00	940801.873
Paper/cardboard	74.9732	10.6	67.026	16747.20	1122497.827
plastics	196.9828	0.2	196.589	32564.00	6401717.683
textiles	48.6500	10.0	43.785	17445.00	763,829.325
leather	27.7396	10.0	24.965	17445.00	435514.425
wood	5.0000	20.0	4.000	18608.00	74432.000
Inorganic					
glass	20.7396	2.0	20.324	139.56	2836.417
Tin cans	11.6520	5.0	11.0694	697.80	7724.227
Ferrous metal	0.0000	2.0	0.000	697.80	0.000
Other metal	4.0000	2.0	3.920	697.80	2735.376
Dirt, ashes, bricks	4.0000	3.2	3.872	69780	27018.816