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ESTIMATION OF GREENHOUSE GASES EMISSION FROM DOMESTIC SOLID WASTE OF FAISALABAD CITY AND SCHEMED FORMULA THEREOF

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Faisalabad is the third largest city and an industrial hub of Pakistan. The current study was designed to measure the harmful gases emitted from domestic solid waste through microbial activities as well as estimate the potential chemical formula of domestic solid waste of Faisalabad city. The dried samples were undergone chemical characterization through the combustion analyzer to evaluate the true picture of the problem that is being associated with domestically generated solid waste. The results revealed frightening impacts on health and environment associated with gases emission from this sector. In the present study, various constituents of municipal solid waste (MSW) were observed to be in the range of 24.16%; 0.87%; 0.14%; 9.2% and 65.62% for C, N, S, H and O, respectively. The mineral matter suggested a good level of minerals in the waste. The C/N ratio was varying from 23.29/0.87% for the compostable fraction of MSW. The screened samples were also analyzed for their elemental percentage. According to the results, 24.16% of C; 0.87% of N; 0.14% of S; 9.2% H and 65.62% of O were found after chemical characterization of almost 1155 tons of domestic solid waste samples collected from the city. It was observed that high percentage of carbon and sulphur while low percentage of ash and nitrogen favors highest heating values with maximum specific energy content. The results suggest that the disposed off could be developed as a source of energy for domestic and industrial purposes.
Keywords: municipal solid waste, carbon, oxygen, Faisalabad, ultimate analysis, chemical formula

INTRODUCTION

The sphere of this study encompasses urban Faisalabad. Despite being the Manchester city of the country, the city does not have an appropriate waste disposal system. The total generated waste of Faisalabad is approximately 1650 tons/day (FWMC, 2015; Zia *et al.,* 2017) among which 1155 tons/day waste comes from residential areas of the city (FWMC, 2015). Sixty percent of the generated waste is collected by Faisalabad Waste Management Company and rest is laying on roads and open plots as heaps. In Faisalabad, common waste disposal practice includes open dumping without any gas collection or leachate control system to shield the resources of the ground and surface water (Ali *et al.,* 2014). The amount of municipal solid waste is increasing day by day with the increase of population in the city and management of this ever-increasing waste in a socially acceptable and sustainable manner has become a problem for establishments (Gomez *et al.,* 2008; Al-Khatib *et al.,* 2015). Untreated waste imposes environmental hazards with an economic cost for inhabitants of the vicinity. For the comfort and health of inhabitants, proper waste management is crucial (World Bank, 1999; Aparcana, 2017; Iqbal et al., 2019).

It is suggested by previous researches and best practices that shifting to a sustainable and environment friendly waste management option needs an optimal combination of numerous management choices such as composting, pyrolysis, recycling, incineration with energy recovery, gasification, instead of single waste management technique (McDougall *et al.,* 2001; Othman *et al.,* 2013). Therefore, the only answer for successful municipal solid waste treatment and disposal is integrated solid waste management (Batool and Chaudhary, 2009; Zia *et al.,* 2017; Iqbal et al., 2019). If authentic data is used in the waste management approach establishment with proper implementation, it will be a great innovation in dropping soil, water and air pollution caused by improper solid waste disposal (Zhao *et al.,* 2011; Jadoon *et al.,* 2014).

The consequence of improper MSW handling and disposal is environmental degradation, which is hazardous to inhabitants (Khan *et al.,* 2016). Various gases especially carbon dioxide and methane are generated along with other non-methane VOC within solid waste disposal sites due to anaerobic reactions. In landfill, the accurate percentage gases distribution varies, but distinctive components found in MSW disposal sites are carbon dioxide 40 – 60% and methane 45 - 60% (Daura *et al.,* 2014). Apart from the release of greenhouse gases (GHGs) into the atmosphere, unintended MSW are causing global warming/climate changes with no energy recovery. It was observed after reviewing various studies that a consistent waste characterization would certainly be a required to assess waste management plans comprehensively (US EPA, 2002; Gomez *et al.,* 2009). Unfortunately, the unavailability of authentic data regarding waste generation rate, its composition and factors affecting them divert the possibility of proper waste management (Guerrero *et al.,* 2013; Bing *et al.,* 2016). If such data are available, these studies of waste characterization can be used as a baseline to outline the plan of optimal waste management (USEPA, 2002; Chifari*et al.,* 2016) using life cycle assessment (LCA) approach (Qi *et al.,* 2017). It is important to characterize waste to achieve baseline authentic data for waste management plan establishment (Feng *et al.,* 2017). For Faisalabad, a sustainable integrated waste management approach is needed that is economically viable and environmentally and socially acceptable, a waste characterization practice is essential to determine the waste generation rate, fractional composition and the factors affecting the municipal solid waste (MSW) which is the objective of the current study.

Although several parallel studies have been conducted around in Pakistan and around the globe (Feniel Phillip *et al.,* 2009; Al-Jarallah and Aleisa, 2014; Denafas*et al.,* 2014; Zia *et al.,* 2017), none have been conducted in Faisalabad. The outcomes of this study can be used as a reference line for the development of an ideal waste management plan in Faisalabad using life cycle assessment (LCA) as well as assessing the environmental burdens imposed by current solid waste management (SWM) approaches. The objectives of the present study include; (1) to estimate the emissions of ultimate analysis for municipal solid waste, (2) to Identify the seasonal and social influences on gases emission and heating values of the collected municipal solid waste, and (3) to derive the chemical formula of domestic solid waste of Faisalabad city.

MATERIALS AND METHODS

***Description of Study Area*:** The current study was planned to quantify the domestic waste generation from the city of Faisalabad, Pakistan (latitude 31°4187′N, longitude 73°0791′E, 184·4m asl) (GPS Co-ordinates, 2018), which is the third largest city of Pakistan comprising a population of 5,429,547 (Pakistan Census, 2017); it was preferred purposely for the research.

***Sampling design*:** For the current study, samples of the Faisalabad city were collected. The domestic source was categorized into high, medium and low class for stratified sampling for 7 consecutive days for all the four seasons. To calculate the waste generation rate average household size used was 7people.Samples were physically segregated followed by chemical characterization. The households in this study were grouped into three socio-economic groups based on following criteria:

(1) Area and structure of the house
(2) Property value of the area
(3) Households average income

The assets values were derivatives of individual statement with the property traders. During the field surveys, area, structure of houses and common domestic earnings were collected. In Pakistan, various earlier studies considered the common earning levels for socio-economic categorization into groups where the monthly earning of high groups is supposed more than (US$953), 1,00,000 Rs, had houses that cover the areas between 1 kanal (4500 sq ft) to 2 kanal (9,000 sq ft) with sufficient space for lawns and gardens, while, middle group earnings is (US$333) 35,000 Rs and low earnings group is (US$95) 10,000 Rs with houses comprising area of 3–5 Marla's (675 to 1,125 sq ft) (Durr-e-Nayab, 2011). The city area was grouped into three socio-economic groups where the population belongs to high earning constitutes 20%, middle earning group constitutes 55% and the remaining 25% placed in low earning category.

From low, middle and high earnings areas, 45 houses were selected randomly from each of four towns in city and appealed to take part in the study of characterization of waste. Each family was given with shopping bags that were labelled with the house numbers. At the end of the day, the bags were collected from each house and properties of waste were analysed by weighing and sorting out several waste portions. These samples were a symbol of the rate of waste collection. The subjective mean for the composition of waste, a study area derived from a total of 5040 waste samples, analysed by sorting of. These samples were collected by hand from 15 houses and from each of the three income categories for seven consecutive days in each of four seasons as represented below:

$$15 \text{ houses} \times 3 \text{ socioeconomic groups} \times 4 \text{ towns} \times 4 \text{ seasons} \times 7 \text{ days} = 5{,}040 \text{ samples} \qquad \text{(Eq. 1)}$$

***Ultimate analysis*:** Ultimate analysis of solid waste is usually a quantitative estimation of the oxygen (O'), total carbon (C'), nitrogen (N'), hydrogen (H') and sulphur (S') percentages after moisture contents and ash residues removal from sample (Tabatabai, 1974; Page *et al.,* 1982) which is accomplished through the use of classic oxidation, decomposition/reduction technique performed in the CHNS analyzer.

***Basic principles of CHNS analyzer operation*:** In the ignition process (furnace at ca. 1000ºC), hydrogen to water; carbon is transformed into carbon dioxide; sulphur to sulphur dioxide and nitrogen to nitrogen gas/oxides of nitrogen. If other elements such as chlorine are existing, they will also be transformed into combustion products, like hydrogen chloride. To remove some of the primary elements as well as additional combustion products, several absorbents are used, Sulphur for example, if these elements are no more required to determine. The combustion products are swept out of the combustion chamber by inert carrier gas such as helium and passed overheated (about 600ºC) high purity copper. This copper can be positioned in a separate furnace or at the base of the combustion chamber. The function of this copper is to eliminate any spare oxygen in the preliminary combustion and to transform any oxides of nitrogen to nitrogen gas. The gases are then passed through the absorbent traps to leave only water, nitrogen dioxide, carbon dioxide and sulphur dioxide. A variety of ways can be used to detect these gases including (i) a GC separation followed by quantification using thermal conductivity detection (ii) a partial separation by GC ('frontal chromatography') followed by thermal conductivity detection (CHN but not S) (iii) a series of separate infra-red and thermal conductivity cells for detection of individual compounds. High purity 'micro-analytical standard' compounds like benzoic acid and acetanilide are used to calibrate each element detected for quantification of those elements.

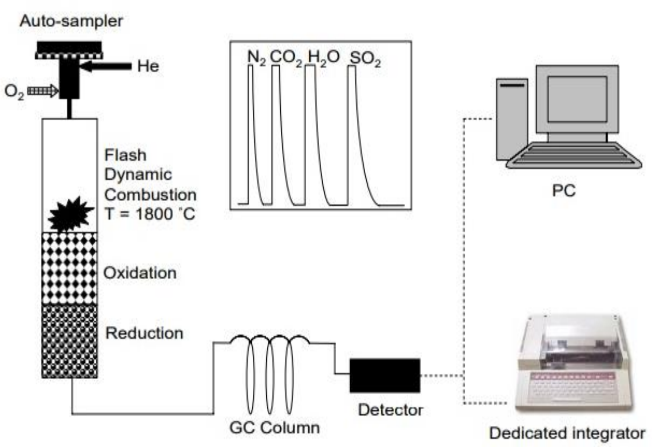

Figure 1. CHNS Elemental Analyzer

Estimation of Oxygen percentage**:** Oxygen is calculated by difference using the following equation (Joel and Eckart, 1986):

$$O_{(w/o)} = 100 - [C_{(w/o)} + H_{(w/o)} + N_{(w/o)} + S_{(w/o)} + M_{o\,(w/o)} + A_{s\,(w/o)}] \quad \text{Equation (2)}$$

The approximate chemical formula of DSW of Faisalabad**:** To estimate the approximate chemical formula of the domestic solid waste of Faisalabad city, the molar composition of each element was determined by dividing them with their respective atomic weight.

- To derive the formula without sulfur, the lowest represented element was used such as nitrogen will be used as the base while each value was divided by the number of moles of nitrogen.
- Likewise, when deriving the formula with sulfur use sulfur as a base and each molar value was divided by the number of moles of sulfur (Munir *et al.*, 2015).

RESULTS

Seasonal influence on characterization (ultimate analysis) of MSW**:** Seasonal samples collected from Faisalabad for all four seasons (winter, spring, summer and rainy) undergo chemical characterization (ultimate analysis) to estimate the emission potential of domestic waste that contributes to environmental deterioration. The results were devastating at all. Fig. 2(a) to Fig. 2(f) describes all the emissions from representative samples collected from Faisalabad city from three socio-economic groups for all seasons on the average. It was estimated that food waste only emits 2423.97 kg oxygen, 496.33 kg of carbon, and 320.57 kg of hydrogen, 26.88 kg nitrogen, 4.14 kg sulphur and 51.70 kg of ash as illustrated in Fig. 2(a). The concentration of oxygen and hydrogen was all about included that available in the moisture content of the collected samples.

Emission quantity for wood and cardboard found in domestic waste was approximately lies in the same range as nitrogen (0.02 kg and 0.05 kg), sulphur (0.01 kg and 0.03 kg) and total hydrogen (0.99kg and 1.09 kg), respectively. While a slight variation was found in the emissions of carbon (5.61 kg and 7.40 kg), total oxygen (7.33 kg and 8.28 kg) and ash (0.17 kg and 0.84 kg) from wood and cardboard described in Fig. 2(b) and 2(d), respectively.

Paper waste seems less damaging but surprising results revealed after analysis report as it generates 2nd highest emissions of these harmful gases after food waste from the four selected components of collected waste among twenty segregated fractions. Residual ash after the ignition was estimated at about 3.7 kg while emitting 30.62 kg total oxygen, 26.85 kg carbon, 4.14 kg of total hydrogen, 0.48 kg of nitrogen and 0.12 kg of sulphur.

Fig. 2(e) and 2(f) represent the outcomes of ultimate analysis for textile and plastic waste. 1.25 kg of ash occupied 0.08 kg of sulphur, 2.31 kg of nitrogen and 27.59 kg of carbon, respectively. While, a very small fraction of plastic was analyzed which emits about 5.95 kg of carbon, 2.46 kg of oxygen and 0.74 kg of hydrogen. There was no significant emission of sulphur and nitrogen was recorded after analysis. The above-described results were obtained from 180 residential units of Faisalabad only during four seasons of the year 2016. While the whole population of Faisalabad ids generated 1650 tons of MSW on a daily basis. If the ultimate adverse impacts of gases emitted from total generated waste of Faisalabad would be estimated, the results will be injurious. There is a need to develop management strategies to handle the MSW not only to minimize it but to produce some energy contents from available renewable resources of MSW.

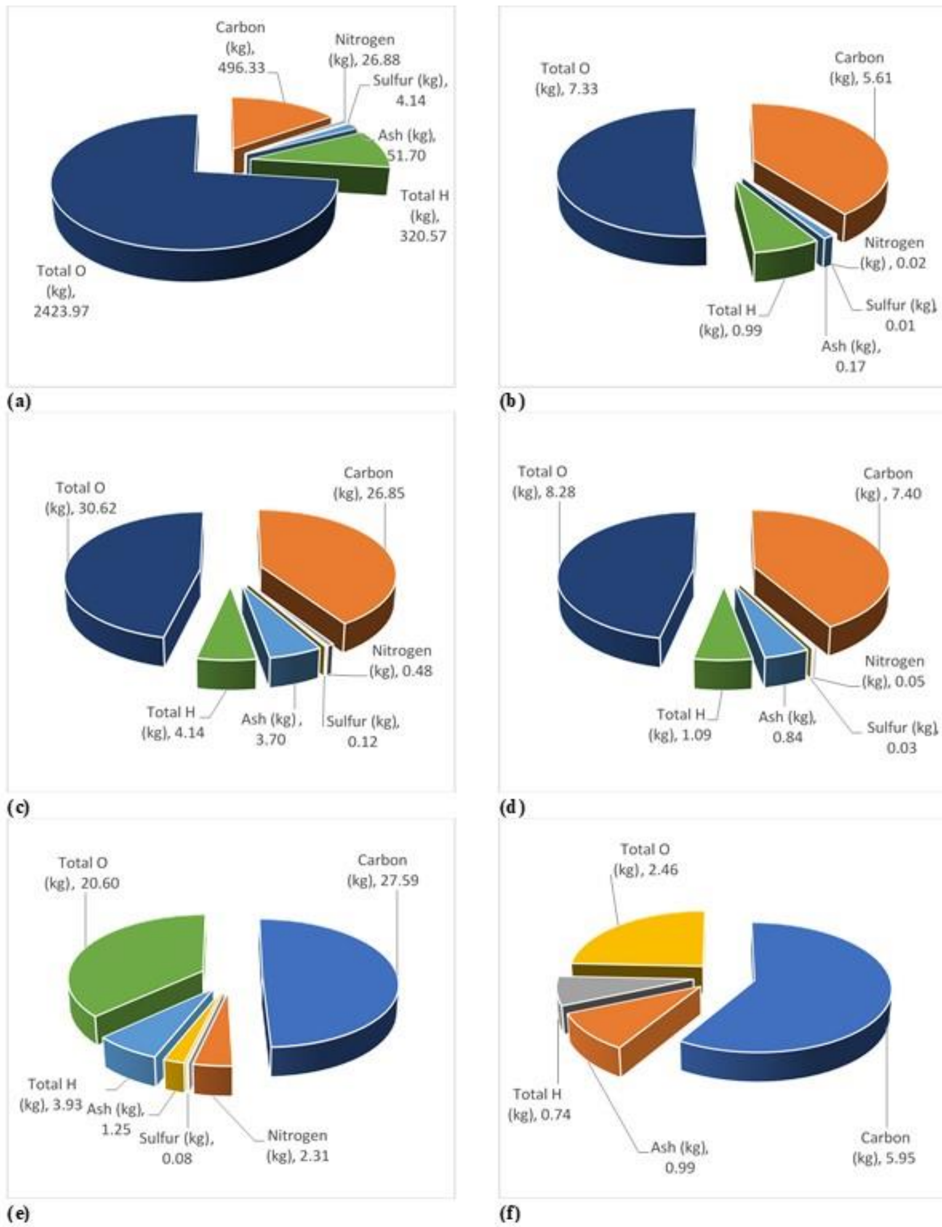

Figure 2. Average fractional percentage of ultimate analysis emission offood waste(a); wood waste (b); mean fractional percentage of analysis emission of paper waste (c); average fractional percentage of ultimate analysis emission of cardboard waste (d); average fractional percentage of ultimate analysis emission of textile waste (e); average fractional percentage of ultimate analysis emission of plastic waste (f)

***MSW characterization (ultimate analysis*):** It was observed from our previous observations and estimations that seasonal variation imposes different impacts on the gases emitted from waste and waste composition generated from different socio-economic groups. Fig. 3(a) and Fig. 3(b) showed the average seasonal influence on the ultimate emissions from the food waste collected from the city.

As in previous studies, food waste was the dominant component of the domestic solid waste from all the three socio-economic classes thus contributing more to pollutant emissions rather than other considerable fractions (wood, paper and cardboard, textile and plastic) as a whole. While plotting a comparison of greenhouse gases emission from food waste of three income classes, it was found the highest carbon emission from food waste collected from the middle class (220.22 kg) followed by emission from high class (230.20 kg) and lower class (167.42 kg). There was no significant difference for the emission of nitrogen, hydrogen,

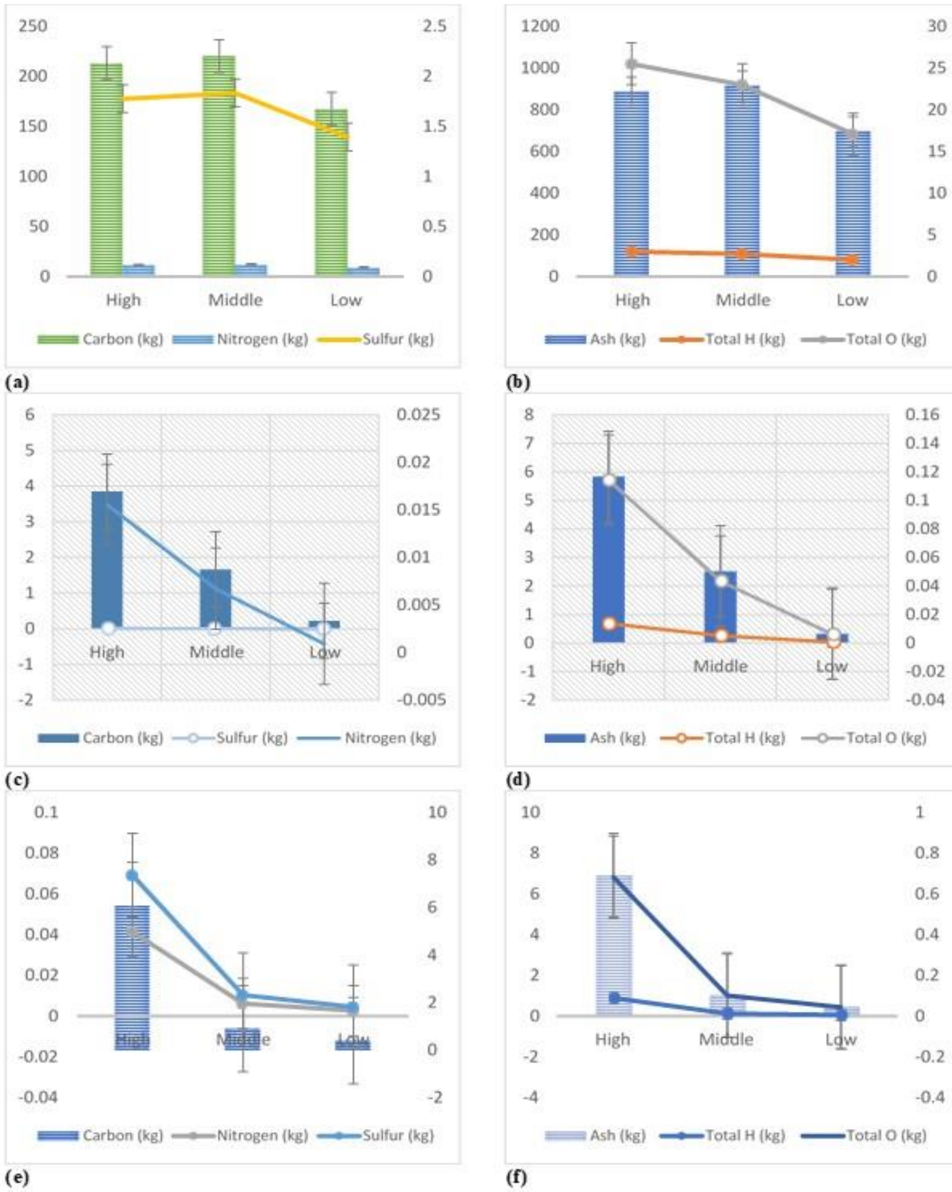

Figure 3. Average fractional percentage of ultimate analysis emission of food waste (a); mean percentage of ultimate analysis emission of food waste (b); average fractional percentage of ultimate analysis emission of wood waste (c); average fractional percentage of ultimate analysis emission of wood waste (d); mean percentage results of analysis emission of cardboard waste (e); average percentage of ultimate analysis emission of cardboard waste (f)

oxygen except sulphur emitted from the food waste collected from lower class (1.4 kg).

While, the highest fraction of food waste emitting highest gases and the fact is revealed after ultimate analysis to whom results are shown in Fig. 2, according to which 220.22 kg of carbon, 11.93 kg of nitrogen, 1.84 kg of sulphur, 109.1 kg of total hydrogen, 810.38 kg of total oxygen and 22.94 kg of ash was released from 1269.03 kg of food waste collected in each season on the average. While people from the lower class were not generated wood as waste because they people are using this waste as a resource to fulfill their needs of firing to cook their food thus comprising significant difference between ash content and other gases emission when compared with other two classes.

The Fig. 3(c) and Fig. 3(d) compare the emission results of wood pallets after ultimate analysis with an approximation according to which 151.36 kg of collected wood as waste from high class of Faisalabad for all the four seasons emit 5.03

kg, 0.68 kg, 3.85 kg, 0.02 kg, 0.01 kg and 0.12 kg of total oxygen, total hydrogen, carbon, nitrogen, sulphur and remaining ash, respectively. While emission of total oxygen, total hydrogen and carbon from the wood waste collected from the middle and lower class were recorded as 1.91 kg and 0.27 kg, 0.26 kg and 0.037 kg, 1.66 kg and 0.22 kg, respectively. A significant difference was observed between the ash contents obtained after ignition of wood pallets collected from three income-groups as waste.

A significant difference in carbon emission was plotted between high (6.09 kg), middle (0.91 kg) and low socio-economic classes (0.40 kg). Much fewer gas emission was found from wood and cardboard waste collected from middle and low-income groups as indicated in Fig. 3 (c) to Fig. 3(f). The fact behind lower emissions was the less fractional percentage of these components in the total waste collected from this income set-up. Most of the people of the middle social class are living in small houses with no plants, trees or

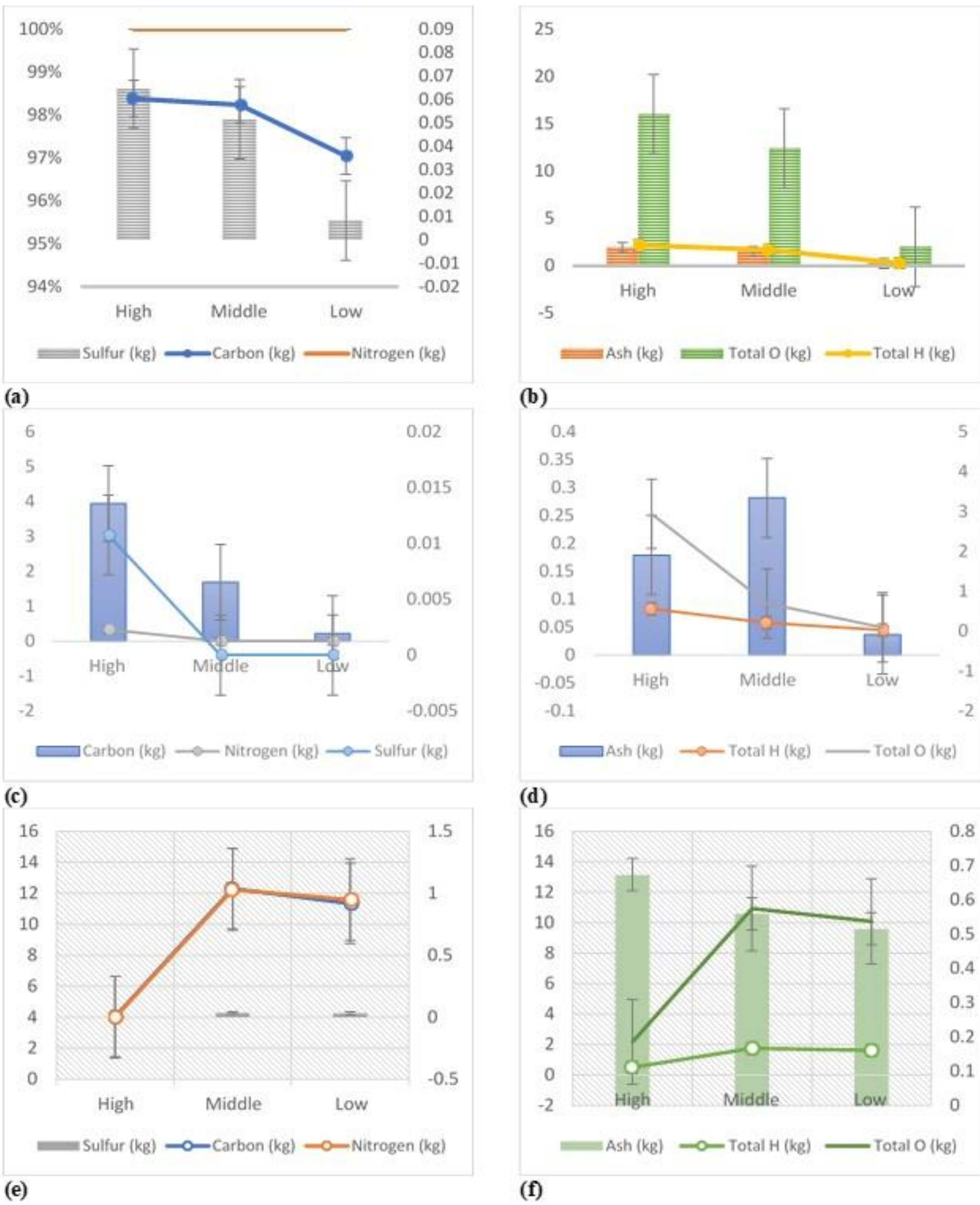

Figure 4. **Mean percentage description of ultimate analysis emission of paper waste(a); average fractional of ultimate analysis emission of paper waste (b); ultimate characterization of plastic Waste on an average basis (c); average fractional percentage of ultimate analysis emission of plastic waste (d); mean fractional percentage of ultimate of textile waste (e); average percentage of ultimate characterization of textile waste (f)**

lawns. Similarly, not all of them having access to most of the facilities like natural gas thus using wood and cardboard pallets if available to cook their food.

When analyzed paper waste collected from three socio-economic classes of the city, no significant difference was observed for carbon and oxygen emission for high (14.04 kg and 11.2 kg) and middle class (16 kg and 12.40 kg), respectively. While a significant difference was obtained for carbon (1.82 kg) and oxygen (1.99 kg) emission from the paper waste collected from the lower class in comparison with the other two classes illustrated in Fig. 4 (a) and Fig. 4 (b). A similar trend was experienced for ash contents, nitrogen, sulfur and hydrogen.

Fig. 4 (c) and Fig. 4 (d) Showed the results of the ultimate analysis for collected plastic waste, a significant increase in carbon emission was experienced from the plastic waste collected from high class (3.94 kg) other than middle class (1.69 kg) and lower class (0.22 kg). While the emission of other gases including ash, the content was not significant enough because of the minute quantity of plastic waste.

Fig. 4 (e) and Fig. 4 (f) represent the results obtained after the ultimate analysis of textile collected as waste in domestic solid waste. Results were surprising to some extent with a significant increase in carbon emission from textile waste collected from middle class (12.30 kg) when compared with high-class carbon emission of similar fraction which was recorded as (4.04 kg). while no significant difference was found for carbon and other ultimate emissions between middle and lower class of the city.

When a comparison was assumed between the social relation of three groups to their environment, the results were injurious. According to our perceptions based on our results, high-income class generating more waste with a variety in its composition as compared to the other two groups but people from the lower class were badly injured due to environmental circumstances imposed by the municipal solid waste due to trans boundary effect. There is a need to pay them some incentives to justify their losses imposed by other classes.

***Chemical formula of domestic solid waste of Faisalabad city*:** While, Table 1 represented the outcomes of the study obtained after the ultimate analysis for domestic solid waste (household waste) of Faisalabad city through formulas by using the results obtained after chemical analysis of domestic solid waste samples. It was observed that an approximate 782.86 tons of combustible waste of 1,155 tons of domestic solid waste emit almost 200063.3 kg of carbon, 61588.05 kg of hydrogen, 419101.72 kg of oxygen, 8413.28 kg of nitrogen and 1294.96 kg of sulfur. The highest greenhouse gas emitter was an organic waste because it covers a major portion of total waste stream. According to the results, 63875.13 kg of carbon gases is emitted from approximately 418.23 tons of organic waste collected from residential sector of city, while 3459.9 kg of nitrogen is emitted on daily basis as per our calculations. In the calculations no significant emission of nitrogen and sulfur was observed for plastic waste that was just thrown in the garbage. Similarly, we have found zero oxygen emission from rubber waste. All the fractional masses of waste were calculated for hydrogen and oxygen with and without moisture contents except rubber, plastic and cardboard.

The results of chemical characterization are devastating; according to which the waste sector is a potential producer of GHGs emissions and poses severe impacts on society equally by disturbing the natural environment and economically through enforcement to spend more money to maintain the health issue. We should keenly notice this sector and focus on waste management to overcome the unnoticed impacts associated with solid waste to flourish a healthy society.

It is crucial to know the chemical composition of waste as it makes the basis for LCA modeling and shakes the final result (Majeed *et al*., 2018). The results described in terms of biogas potential, leachate production, emissions/kg or concentrations of several pollutants etc. are dependent on the chemical properties of waste. The molecular composition (C, H, O, N, P, etc.) is the most important in estimating the burdens on the environment associated with different waste management activities and to assess the alternative options for recovery and waste processing (Majeed *et al*., 2018).

***Chemical formula of DSW of Faisalabad city*:** After calculations of chemical analysis, we determined Molar Composition of the Elements, Neglecting Ash by dividing each component by its respective molecular weight to derive the chemical composition of the domestic solid waste of

Table 1. Ultimate analysis results of total DSW/day of Faisalabad city

Elements	Carbon (C) kg	Hydrogen (H) kg		Oxygen (O) kg		Nitrogen (N) kg	Sulfur (S) kg
		H with H_2O	H without H_2O	O with H_2O	O without H_2O		
Organic Waste	63875.13	35976.23	8516.68	269711.88	50035.52	3459.90	532.29
Yard Waste	19474.59	9234.81	2444.51	69804.32	15481.90	1385.22	122.22
Wood	4449.60	789.04	539.35	5835.92	3838.34	17.98	8.99
Paper	20006.36	3085.68	2759.50	22845.77	20236.32	137.97	91.98
Cardboard	13212.60	1947.30	1771.69	14797.62	13392.77	90.09	60.05
Plastic	26246.19	3247.72	3149.54	10758.99	9973.55	---	---
Rubber	18859.83	2472.77	2417.93	---	---	483.59	386.87
Textile	33939.00	4834.50	4072.68	25347.22	19252.67	2838.53	92.56
Total	200063.30	61588.05	25671.88	419101.72	132211.07	8413.28	1294.96

Faisalabad city. To derive the chemical composition of domestic solid waste of Faisalabad city, all the emission elements were calculated in grams as described in Table 2. It was found that there was no difference in number of moles of elements except hydrogen and oxygen because of moisture contents in each fractional mass of solid waste collected from the city of Faisalabad. A similar trend was found when estimating number of moles of each element by dividing by its atomic weight already defined in the periodic table. Higher numbers of moles were observed for hydrogen and oxygen while calculating with moisture content of each selected waste fraction (Table 3).

Table 2. Distribution of the elements with and without water

Element	Moles	
	W/O Water (g)	W/ Water (g)
Carbon (C)	272198925.00	272198925.00
Hydrogen (H)	33919849.00	73286503.00
Nitrogen (N)	9773592.64	9773592.65
Sulphur (S)	1839100.73	1839100.73
Oxygen (O)	138190285.50	452684897.20

Table 4 presented the normalized molar ratio of elements emitted from domestic solid waste at various stages. Approximate Chemical formulas obtained from the calculation in Table 4 for the domestic solid waste of Faisalabad are $C_{32}H_{104}O_{41}N$ (with water) and $C_{32}H_{48}O_{12}N$ (without water) without sulfur. While, approximate chemical formulas of domestic solid waste of Faisalabad city while considering sulfur is $C_{395}H_{586}O_{151}N_{12}S$ without water and $C_{395}H_{1265}O_{493}N_{12}S$ with water. All the values in formulas are in whole numbers (Techobanoglous *et al.*, 1977 reported by Munir *et al*., 2015).

DISCUSSION

Improvement in the sector of waste management during the past decade has converted the simple collection method of unsorted waste and its dumping to landfills into an organized, integrated system (Parkes *et al.*,2015; Majeed *et al.*, 2018). The physical composition of waste is the major factor that governs the greenhouse gases generated during waste management (Chen and Lin, 2008). It was observed that the waste generated from domestic areas of the city and its composition is not homogeneous. They vary according to changes in population behavior, commercial activities, consumption patterns and economic growth rates as well as depend upon the seasonal fluctuation of the year weekdays.

Finally, the characterized results of waste samples were then used to calculate the overall emissions from total domestic solid waste generated from Faisalabad city. Almost 1155 tons of domestic solid waste is generated daily in the area (FWMC, 2015). It was observed that almost 289 tons of solid waste are source-separated at the domestic level. Only 60% of the total generated waste is collected while rest 40% remains on streets, parks and open parks (FWMC, 2015). Because of inadequate waste separation systems, nearly all these waste categories end up in the form of open dumping on the disposal site, which ultimately becomes a source of environmental and health hitches. For example, because of the absence of appropriate landfills, the leachate from organic waste is polluting the groundwater. The issue can easily be evaded by separating this element to make compost. Greenhouse gases emission from disposal site would subsequently reduce (Ali *et al*., 2014), though the higher moisture content in municipal solid waste would prerequisite to be catered first.

Diverse municipal solid waste is disposed of in piles in disposal sites of FWMC (Faisalabad Waste Management Company) without suitable dispersal and compaction, which causes a profane smell and polluted conditions. The MSW is dumped at the disposal site without following any separation and smearing daily soil covers. At the disposal site, FWMC has no provision for the collection of leachates, so it may easily discharge into already contaminated soil as well as underground water. The ultimate impact of open dumping on the surrounding environment and water resources is completely neglected to date.

In the present study, various constituents of MSW were observed to be in the range of 24.16%; 0.87%; 0.14%; 9.2%

Table 3. Percentage distribution of the elements with and without water

Elements		Carbon (C)	Hydrogen (H)	Oxygen (O)	Nitrogen (N)	Sulphur (S)
Atomic Weight		12.01	1.01	16.00	14.01	32.07
Moles	W/O Water	22664356.79	33584008.91	8636892.84	697615.46	57346.45
	W/ Water	22664356.79	72560894.06	28292806.08	697615.46	57346.45

Table 4. Normalized mole ratio of elements

Elements		Carbon (C)	Hydrogen (H)	Oxygen (O)	Nitrogen (N)	Sulphur (S)
Moles Ratio (Nitrogen=1)	W/O Water	32.49	48.14	12.38	1.00	0.08
	W/ Water	32.49	104.01	40.56	1.00	0.08
Moles Ratio (Sulfur=1)	W/O Water	395.22	585.63	150.61	12.16	1.00
	W/ Water	395.22	1265.31	493.37	12.16	1.00

and 65.62% for C, N, S, H and O, respectively. The mineral matter suggested a good level of minerals in the waste. The C/N ratio was varying from 23.29/0.87% for the compostable fraction of MSW. The screened samples were also analyzed for their elemental contents. The results clearly indicate that carbon and oxygen are the major constituent elements in the screened MSWs. Baawain *et al.* (2017) proposed similar findings in their study conducted in Muscat.

In developing countries, municipal solid waste can be used to augment the energy demand of the nation that is a renewable resource and is available in abundance. Ineffective biomass solid waste utilization constitutes pollution and environmental hazard and also releases strong irritating smell due to microbial decomposition activities at disposal sites. These facts required quantification, characterization and effective translation of these readily existing byproducts to produce energy.

This study demonstrated that the calorific value of municipal solid waste can be enhanced by dropping its moisture content and this can be attained by sun drying. Approximate Chemical formulas obtained from the calculations in Table 4 are $C_{32}H_{104}O_{41}N$ (with water) and $C_{32}H_{48}O_{12}N$ (without water) without sulfur. While, approximate chemical formulas of domestic solid waste of Faisalabad city with consideration of sulfur is $C_{395}H_{586}O_{151}N_{12}S$ without water and $C_{395}H_{1265}O_{493}N_{12}S$ with water (Techobanoglous*et al.,*1977 reported by Munir *et al.,* 2015).

A significant level of methane could be generated by anaerobic decomposition of this organic fraction of waste at dumpsites/ uncontrolled landfill sites. Furthermore, this substantial organic portion of the waste may possess a threat to human health as it will attract rodents and other disease vectors to the collection and dumping sites (Gupta *et al.,*1998).

This study was designed to determine the quality as well as the synergetic effect of the ultimate analysis of the municipal solid waste of Faisalabad. The results of the classification and ultimate analysis of the municipal solid waste and the bar chart illustrations of the combined effect of season and socio-economic status on ultimate analysis were also presented. The data generated in the ultimate analysis could be useful in the design of the processes and facilities to utilize the waste. Chemical characterization of solid waste will help to decide and set up good waste disposal and processing facility in the city as well as inefficiency determination of waste treatment procedure.

Suggestions and Recommendations: Presently, no waste treatment services are working in Faisalabad city and waste management merely is a linear system of waste collection and then disposal without any source separation which will ultimately create environmental and health hazards. There is a crucial need to mature a complete municipal solid waste management system derived from the cradle-to-grave technique. The municipal solid waste management is a multifaceted task, the achievement of which is primarily ruled through a combination of public support and the appropriate choice of waste processing amenities.

Conclusions: This study was conducted in the city of Faisalabad (Manchester city) of Pakistan to measure the deteriorating impacts of domestic solid waste on environment and to estimate the energy potential of daily generated solid waste of the city. The results revealed that solid waste if properly managed and processed can compete in the market to combat the energy deficiency in terms of electricity supply. It was observed after keen view of results that higher the level of carbon and Sulphur would ultimately favor with higher energy contents and heating values of respective waste component, while higher nitrogen percentage will lower the specific energy content and heating value. Approximate Chemical formulas obtained from the calculations are $C_{32}H_{104}O_{41}N$ (with water) without sulphur and $C_{395}H_{1265}O_{493}N_{12}S$ with water considering Sulphur. On the other hand, estimation of capacity potential of domestic waste presented is calculated on the basis of MSW collection Capabilities of Faisalabad Waste Management Company (FWMC). The capacity can be improved by improving the waste collection system of concern organizations.

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