An Analysis into Municipal Solid Waste Generated from Selected Wards at Dhaka North City Corporation

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A project and thesis submitted to the Department of Civil Engineering at Daffodil International University, Bangladesh in partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Civil Engineering

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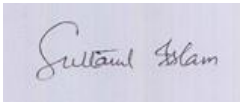

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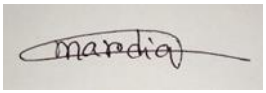

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Candidate's Declaration

It is hereby declared that except for the contents where specific references have been made to the work of others, the studies contained in this thesis are the result of investigation carried out by the author. No part of this thesis has been submitted to any other University or other educational establishment for a degree, Diploma or other qualification (except for publication).

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Finally, we would like to express a very special indebtedness to our parents whose encouragement and support were a continuous source of inspiration for this work.

Dedication

This thesis is dedicated to our family, teachers and friends. Their continuous inspirations made this effort possible.

Abstract

Waste is part of everyday life besides all of us, but it tends to be less likely that citizen cares about it, at least developing countries lacks focus. Moreover, population is growing very rapidly in cities and shaping size an increase day after day. Inadequate steps towards management and planning further blow up the situation. But there is hope for developing world as technology and data driven approach is omnipresent to all forms of life. In this study landfill data was sorted out using spreadsheet to find pattern and made analytics. Landfill data from Amin Bazar used for the work which contains waste from eighteen wards, ward no 1 to 18, of DNCC. The analytics were generated both ward and month wise from February 2019 to September 2019. A close observation by the authors finds correlation and disparity among ward and seasonal basis. The highest and the least always corelates throughout the given time horizon. But dissimilarity among dry month of March found where several wards oppose the norm. Wards also changes its pattern by different time horizon, for instance, ward no. 7 and 13 changes in volume among months. However, most indifferent ward was 2,8,12 and 15 as all of them look very similar. Numerous factors should consider for tangible outcome of the study. It can help the authority to make informed decision by knowing ward specific waste generation and to design efficient means of waste management.

Contents

List of Figures

List of Abbreviation

ANN	Artificial Neural Network
DCC	Dhaka City Corporation
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DSCC	Dhaka South City Corporation
GDP	Gross Domestic Product
GIS	Geographical Information System
HDI	Human Development Index
HWRC	Household Waste Recycling Centers
MSWM	Municipal Solid Waste Management
SWM	Solid Waste Management
UR	Unemployment Rate
WMD	Waste Management Department

Chapter 1

Introduction

1.1 Background

Waste is an unavoidable by product of human activities and Economic developments. Urbanization and population growth are improving living standards in cities. However, it can also have led to an increase in the volume and complexity of generated waste. Rapid urbanization largely responsible for increasing rate of solid waste generation in Bangladesh and facing adversity as the amount of waste generated from domestic and commercial activities is increasing day-after-day in the large cities including the megacity Dhaka. (DoE Bangladesh, 2013) This has a big threat to the environment and public health.

In late 2011, Dhaka City Corporation has divided into Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) for administrative convenience. Both the City Corporations have their own Waste Management Department (WMD). Waste Management has a concern for all the citizen as it ensures the protection of the environment and human health.

Dhaka North City Corporation (DNCC) is situated in the northern part of Dhaka City and consists of 54 wards. The total area of DNCC is about 196.22 sq. km (DNCC, 2020). DNCC focuses on the Municipal Solid Waste management through collection, transportation and dumping. In a year it handles about a million tons of solid waste with its available resources. However, it remains a constant challenge for DNCC because of population dynamism and multiple sources of generation. With the rapid growth of urbanization, the challenges are multifarious and even after all out efforts, at times, it goes beyond the capacity to keep it within control. Landfill is a place where municipal solid waste completely degraded biologically, chemically and physically. DNCC has only one landfill in operation located at Amin Bazar.

Figure 1. Waste collecting and disposal

Sources: http://bmdf.portal.gov.bd/

1.2 Amin Bazar Landfill

The final disposal of solid waste is done in landfill sites. From containers, the wastes are transferred to landfill sites. Landfill sites are depository of the final residuals of solid waste after re-use, re-cycle and reduction. Considering the scarcity of land and density of household, the landfill of DNCC is situated outside of Dhaka city which is at Amin Bazar, Savar. The Amin Bazar landfill site is situated within the low-lying floodplain of the Karanachhali river in Savar Upazila, Dhaka. The area is located at 23°47′48″N and 90°17′50″E. The area is used as a dumpsite from 2007 and at the first stage of its operation it was an open dumpsite. Now this site possesses the characteristics of sanitary semi-aerobic landfill site which facilitates rapid decomposition of wastes with the total area of about 52 acres. The area is inundated during each monsoon between June to October. There are two villages, Konda and Baliarpur, within a distance of 1 km from the site. Landfill operating cost is TK. 134.00/ton (Bangladesh Municipal Development Fund, 2018)

Figure 2. Waste dressing at Amin Bazar landfill

Source: http://bmdf.portal.gov.bd/

Figure 3. Compaction of waste by chain dozer at Amin Bazar landfill

Sources: http://bmdf.portal.gov.bd/

1.3 Objective of the Thesis

i) To investigate current scenario of solid waste generation in ward no 1 to 18 of DNCC ii)

To find a pattern of waste generation and make analytics

1.4 Scope of the Thesis

The prime purpose of this research is to evaluate and compare the weight of solid waste generated ward wise and month wise by using landfill log to know future prospect of the city.

1.5 Organization of the Thesis

Complete research work for achieving the stated objective is divided in number of chapters so that it can be easier to understand the chronological development of the work. Briefly the contents of each chapter are presented below:

Chapter One describes the background of this study, objectives, scopes of the thesis. Finally, the organization of the thesis is summarized in this chapter.

Chapter Two illustrates general overview of literature that has been reviewed prior to start this work. Most important point of the chapter was sustainable management practices, composting, recycling, effects of landfilling and poverty alleviation.

Chapter Three focuses primarily on the notion that leads to data collection and analysis. In that sense, it could be positioned as threshold which later become a reality.

Chapter Four however, demonstrates key findings of the work.

Chapter Five was concluding part also figures out some shortcoming of the work.

Chapter 2

Literature Review

2.1 Overview

Throughout the human history, the amount of waste generated by humans was insignificant due to low density. In most developed countries, domestic waste disposal is funded from a national or local tax which may relate to income, or property values. Commercial and industrial waste disposal is typically charged as a commercial service, often as an integrated charge which includes disposal costs. This practice may encourage disposal contractors to opt for the cheapest disposal option in that case landfill rather than environmentally best solution such as re-use and recycling. Areas with developing economies often experience exhausted waste collection services and inadequately managed and uncontrolled dumpsites.

2.2 Solid Waste Management Practices and Government Roles

Waste management, a challenging task due to the increase of population and inadequate practice of waste management. Socio economic factor, seasonal factor, demography, lack of awareness is also responsible for this haphazard. Uncollected waste of Dhaka city dumped in open space and clog the drainage system which creates health hazards and environmental degradation mainly in the monsoon. successful waste management system can help to improve the overall scenario of DNCC (Yasmin and Rahman, 2017).

Initiated action of empowering, establishing community-based segregation at source, waste recycling and treatment option need to be addressed for resource recovery. Both national and local level partnership can assist to increase the awareness and enhance the livability of the city (Wang et al., 2020).

The effect of composting on disposal of solid waste and effect of landfill site location has been analyzed. Existing SWM system of the Dhaka city reflects inadequacy furthermore generation and characteristics of solid waste dictates environmental degradation. Rate of generation forecasted to rise exponentially and by composting methane generation might be lessen up to half. In addition, Inside the city acute shortage of necessary land in future hampers landfilling activity (Hai and Ali, 2005). Community based solid waste management

system with recycling and conjunction with sanitary landfilling station can help to mitigate the problem.

(Brunner and Fellner, 2007) found that for regions spending less for waste management, the `waste hierarchy' of prevention, recycling and disposal is not an appropriate strategy. In such regions, the improvement of disposal systems (complete collection, upgrading to sanitary landfilling) is the most cost-effective method to reach the objectives of solid waste management.

Role of governance in solid waste management is key concept to make city better. But city government failed reach service users. Private and community initiatives that have succeeded in reaching the service users, this should share the service delivery responsibly. A well-built public– private partnership can ensure effective solid waste management and good urban governance in Bangladesh. Partnership emerged as an instrument for better service delivery (Bhuiyan, 2010).

2.3 Sustainability and Economic Prospect of Solid Waste

Solid waste management (SWM) shares an enormous burden for the government and also particularly a pivotal point for sustainable Dhaka city. MSW tends to be excessive amount in food waste which has a great potential of Composting, it could be useful to resolve as composting can help to lessen environmental emission (Behrooznia et al., 2018).

A team of researcher in Karachi suggest that, the city has a potential of generating 90 Gg of methane annually through the anaerobic decomposition of organic waste and a good monitored recycling sector can generate a revenue of over 20 million US dollars annually (Khan et al., 2018).

(Wilson et al., 2006) have reviewed the general characteristics of informal recycling, highlighting both positive and negative aspects. Despite the health and social problems associated with informal recycling, it provides significant economic benefits that need to be retained. Experience shows that it can be highly counterproductive to establish new formal waste recycling systems without considering informal systems that already exist. The preferred option is to integrate the informal sector into waste management planning,

building on their practices and experience, while working to improve efficiency and the living and working conditions of those involved. Issues associated with integrating informal recycling into the formal waste management sector were discussed.

The municipal solid wastes were comprised of plastics paper, glass, garden waste, food stuffs industrial stuff which can be a source of compost because 72 percent of waste found organic. Revenue can be generated annually 112.9 million and 86.7 million BDT if it was recycled properly and composted properly from the organic waste (Islam et al., 2015).

Poverty alleviation has the main agenda for most developing country. Well planned and monitored picking activities could reduce poverty also could assure sustainable livelihood in waste workers. A survey of 436 poor waste workers living in the Dhaka shows that up to 2% of the population is surviving through informal waste (Rahman et al., 2017).

2.4 Technology and Uses of Data for Solid Waste Generation

Citizens increasingly dispose their waste at household waste recycling centers (HWRC). The planning of these centers requires a comprehensive understanding of collected solid to enhance the collection of recyclables materials. To fill this knowledge gap, historical data were analyzed with regards to temporal and geographical variation. The results showed the mass of collected waste varies seasonally. Moreover, the data revealed that the total waste collected was principally driven by the number of residents (Edjabou et al., 2019).

A harmonized multiregional solid waste generation is assessed which, covers 48 world regions, 11 types of solid waste, and 12 waste treatment processes. A multiregional supply and use table were used to build a waste-input-output model of the world economy to quantify the solid waste footprint of national consumer. Patterns of waste generation differ across countries and Solid waste footprints are strongly coupled with affluence (Tisserant et al., 2017).

A group of researchers used the most popular non-linear models, artificial neural network (ANN) to successfully predict municipal solid waste (MSW). ANN models for MSW prediction in mainland China are developed and optimized. Models for MSW prediction in southern and northern region of mainland China share much similarity in dependence on

predictors, which differs a lot from that for western region. Results show that regional difference has huge impact on MSW prediction. large-scale based model can be used by cities lacking historical data for prediction of their local MSW generation, the predictive result would be helpful in MSW disposal planning and the analysis of regional difference would be helpful in establishing regional policy (Wu et al., 2020).

Relationships between the household solid waste generation rate and the socioeconomic parameters are quantified, such as household size, total family income, education, occupation and fuel used in the kitchen. Multiple linear regression technique was applied to develop the two models, one for the prediction of biodegradable MSW generation rate and the other for non-biodegradable MSW generation rate for individual households of the city Dhanbad, India. The accuracy tests of the developed models showed convincing results, as the predicted values were very close to the observed values. (Kumar and Samadder, 2017).

Socioeconomic and development indices can influence solid waste generations. Appropriate policies to reduce waste generation can improve standard of life, several studies have been performed at a regional or municipal level to study the impact of socioeconomic factors on waste generation. The impact of the Gross Domestic Product (GDP), the Human Development Index (HDI), the Unemployment Rate (UR), and the CO_2 emissions was addressed. Regression modeling between the waste generation rates and each of the four indices was developed and significant correlations were calculated. Results revealed that solid waste streams were positively correlated to the GDP (Namlis and Komilis, 2019).

Municipal Solid Waste (MSW) disposal sites identification and appropriate management is a challenging task to many developing countries like Bangladesh. Increasing population levels, rapid economic growth and rise in community living standard, accelerates the generation rate of MSW. It shows that application of GIS is an efficient and low-cost tool to study and select appropriate dumping site to facilitate decision making processes. (Mirpur-Pallabi) of Dhaka North City Corporation (DNCC) (10.40 km^2) is a residential area, from where about 353.34 ton/day solid waste is generated and among them about 57.43% were managed by DNCC. Geographical Information System (GIS) was used to propose an efficient scenario with relocating the existing waste collecting containers and increasing number of containers to attain an 93.68% waste collection efficiency including optimization and selection of waste collecting routes (Islam et al., 2016).

Chapter 3

Materials and Methods

3.1 Source of Data

Raw data of landfill obtained from Dhaka north city corporation (DNCC). Raw data has been the main source of information for this study. The sources of the raw data were collected upon submitting application into DNCC office. Data has been received in monthly basis with cooperation of the management. Data which was received from DNCC contains various information such as serial numbers, Date and Time of entries, Ward numbers, Gross weights, Tare weights and Net weights of garbage truck etc. There was a large volume of data that increases extra complexity due to formatting and software compatibility issues.

3.2 Instruments

Since, it was mainly data analysis type work, participants of the work rely on computers and different applications such as Microsoft Word, Excel, PowerPoint, Adobe Acrobat Pro DC etc. Internet plays vital roles even though most essential and critical data were manually shorted and took significant amount of time.

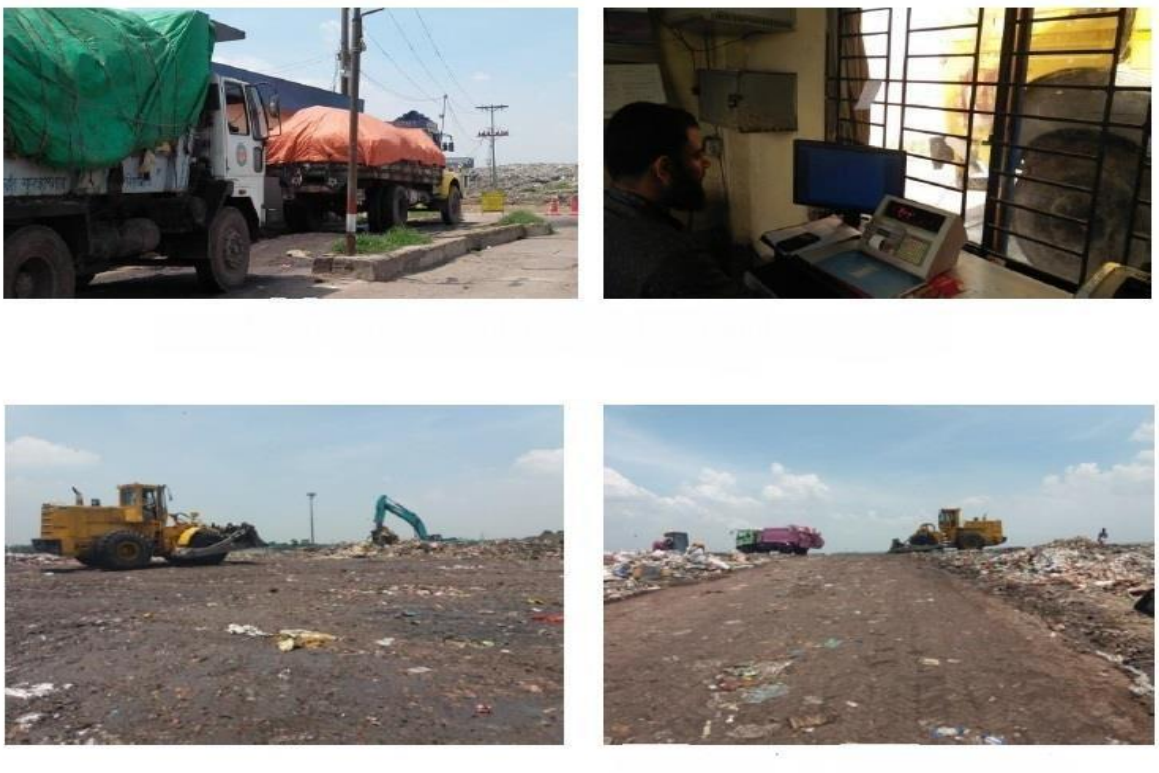

Figure 4. Waste carrying and recorded at Amin Bazar landfill

Source: http://bmdf.portal.gov.bd/

3.3 Data Analysis

First phase of data was received in the month of February. Even though it was only about last 10 days of data it was seem a difficult task because, data was a like an entry-log of landfill site where all garbage truck entry time, weight, source ward number etc. were recorded. It was discovered that in a typical day there was up to 600 such entries from all 36 wards. Due to the complexity of large sum of data in this work, ward number 1 to 18 was only reflected.

Upon receiving the data which was primarily on the basis of Microsoft word there was a process to convert data from Microsoft word to Adobe Acrobat Pro DC software. In addition, the data needs a change to make it compatible so that this can fit to Microsoft Excel. Microsoft Excel was used for the purpose of data sorting and analysis. It works well most of the time although due to technical difficulties sometimes it needs to put data manually.

After initial processing of data, it is now suitable to work with. By making the data even simpler information such as vehicle type, vehicle ID, time was removed. There were six types of data to consider which is serial number by entries, ward number, Gross, Tire, Net weight and date. To make information more interpretable it sorts out in daily basis and ward by ward. Now it is available to show that in a given day in a ward what volume of waste it generates which is a good indicator. It can also be easily comparable among wards to know the highest generation. Furthermore, there is now a possibility to compare in a daily basis which can also indicate that whether it was normal or there was an extra surge in generation due other factors. However, main focus of the work was weight of MSW by ward in a particular month and weight per month by each ward.

Weight of MSW by ward is a measure that can help to understand and compare among wards. By knowing ward to ward MSW generation it may able to track the pattern in short time or monthly basis. Although this can also be comparable among months or seasonal basis. Changes in volume due to dry and wet atmospheric environment is obvious in solid waste thus long term or year-round analysis can enhance the precision of the analysis.

Chapter 4

Results and Discussion

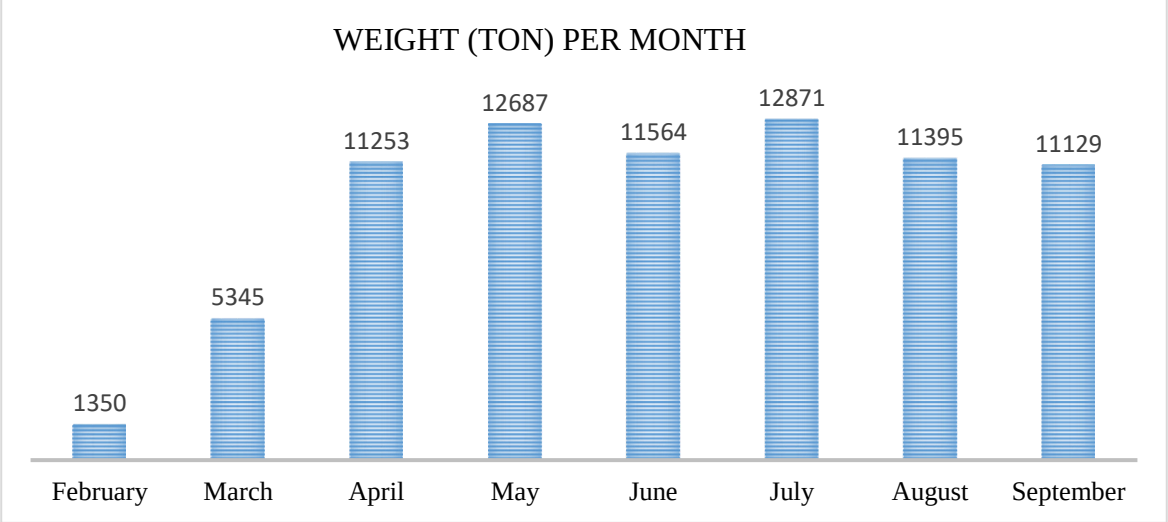

Figure 5. Comparison of solid waste generation at ward no. 1

4.1 Ward No. 1

To begin with the first ward which was Uttara Model Town and surrounding area including Abdullahpur (partial), purakorai (partial), shailpur (partial), Faydabad (partial), Baunia (partial), Dokkhinkhan (partial) Ranavola (partial) and comprising a total area of 6.095 Sq. km and a total number of holdings 5823. It was seen that from April to September rate of generation was almost identical and only March shows a significant drop of nearly half by all other months. The drop was suspected due to change in precipitation. For instances, Dhaka experiences a hot, wet and humid tropical climate. Generally, February and March are last month of winter resulting a dry atmosphere following a wet summer from April onward. Thus, In the wet months weight tends to be higher as compared to dry months. In addition, there has been a reasonable fact to mention that, the ward is highest among all other ward in terms of rate of generation underling reason behinds this was size of the area it also belongs to highest number of holdings.

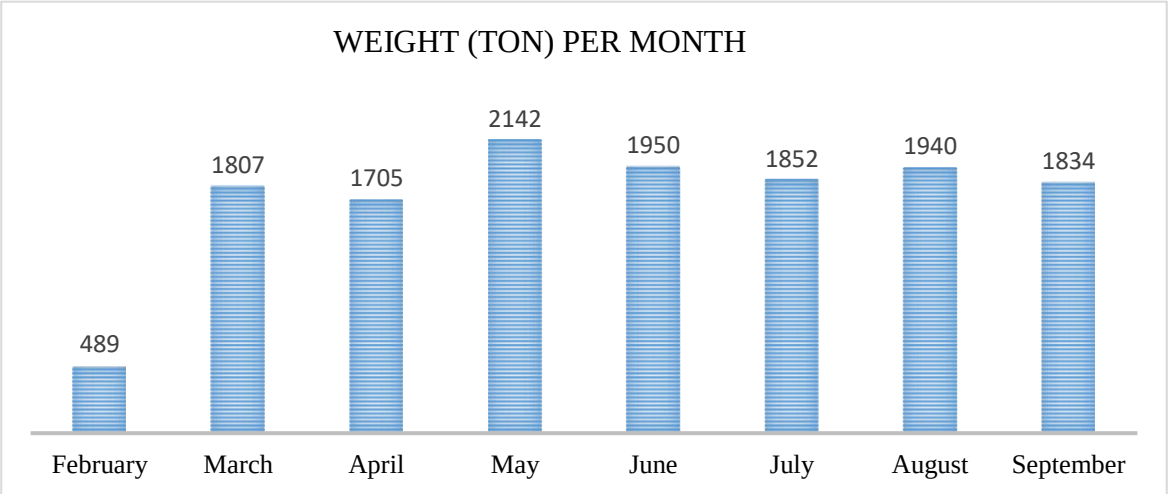

Figure 6. Comparison of solid waste generation at ward no. 2

4.2 Ward No. 2

The rate of generation is not always varied. In ward no. 2, which was the area of North Kalshi section 12, Block B, Block C, Block D, Block E, Block T, Block DHA, Block KA. Section 9, Block Kha, Burir tek. Kalshi Shorkar Bari, Block Pa, Continuous Shagupta a total 3.048 sq. km and total number of holdings 3118. No notable changes in the volume of waste were observed as per data shown above except February. It was half in size compared to ward no. 1 although weight was five times less.

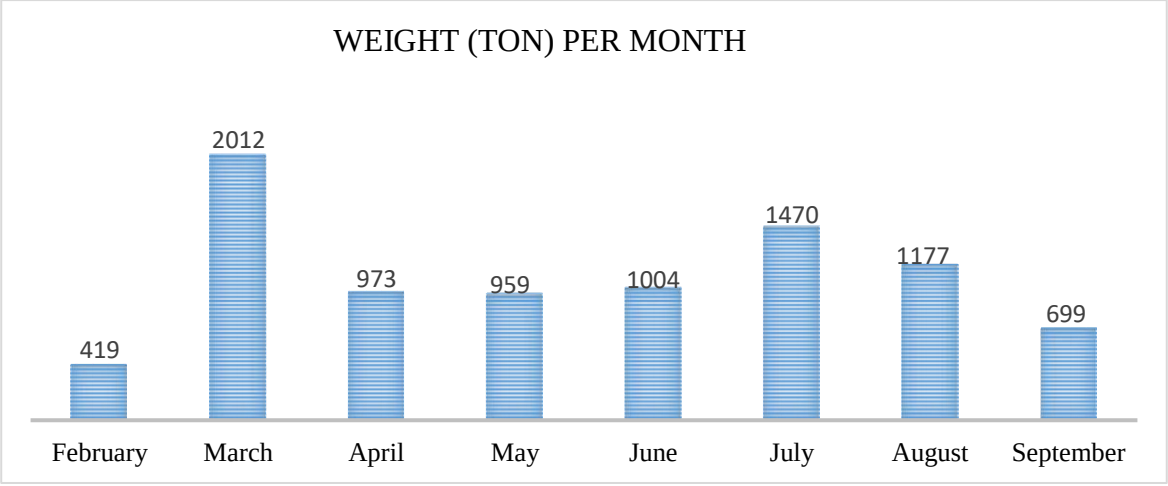

Figure 7. Comparison of solid waste generation at ward no. 3

4.3 Ward No. 3

At ward no. 3, it was evident that there was something unusual happening as the dry month of March was the highest in volume and the considerable amount of rise also been recorded.

To mention constitutes namely Modina nagar Section 10, Block A, Block C, Block D, Section 11, Block C and total area of 1.101 Sq. km and total number of holdings 4902. Not only it has a smallest area but also has a difficulty to spot the reason for anomaly in the month of March as it shows a different direction in the analysis.

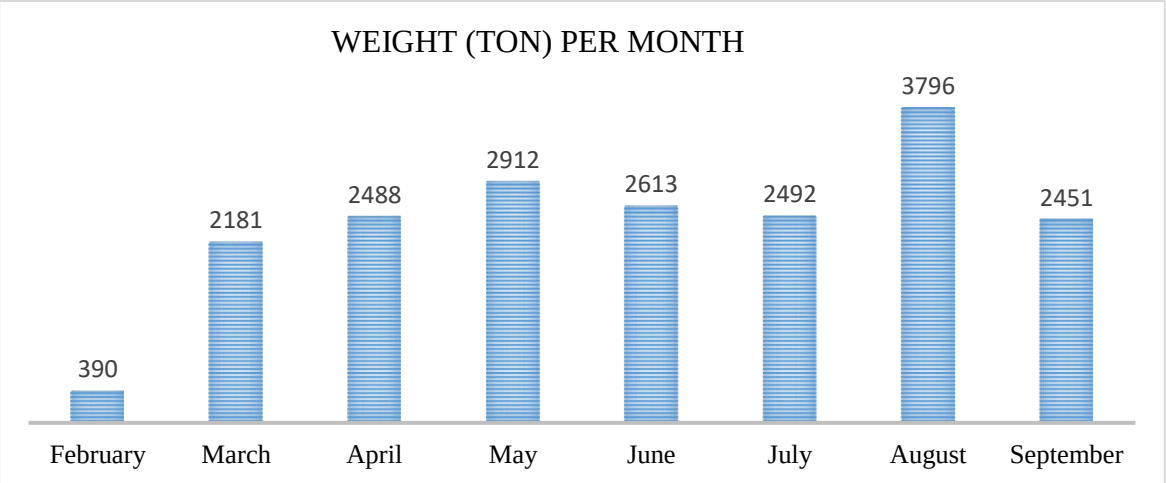

Figure 8. Comparison of solid waste generation at ward no. 4

4.4 Ward No. 4

Ward no. 4 has exceptional pattern as the month of august shows highest and contributing reason behind this is unknown whereas other months produce almost the same amount of waste. This ward located at Mirpur Section 12, Section 14 and Baishteki. Total area of ward no. 04 is 1.338 Sq. km and total number of holdings 1361.

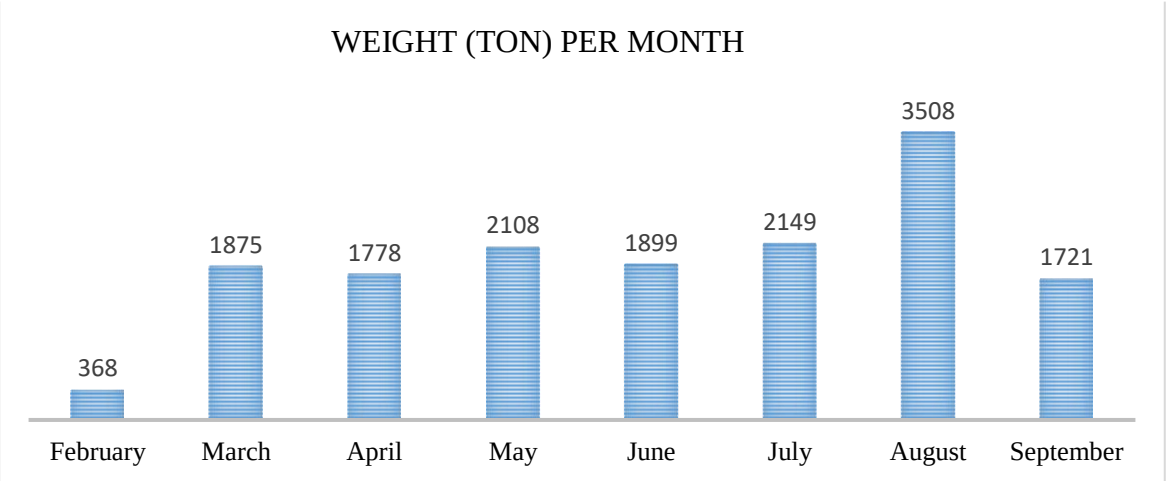

Figure 9. Comparison of solid waste generation at ward no. 5

4.5 Ward No. 5

This shows almost similar pattern as it recorded in ward no. 4 fact to mention, as because they were neighboring ward. In addition to that, they both had almost same size but different number of holdings. This ward is a part of Mirpur Section- 11, Block- A, B, D, E, Baunia Beribadh, Palash Nagar. Total area of ward is 1.3444 Sq. km and total number of holdings 2190. Holdings could not help to determining the factor that affects contribution of waste as it shown even though it has higher holdings it generates less compared to neighboring ward no. 4.

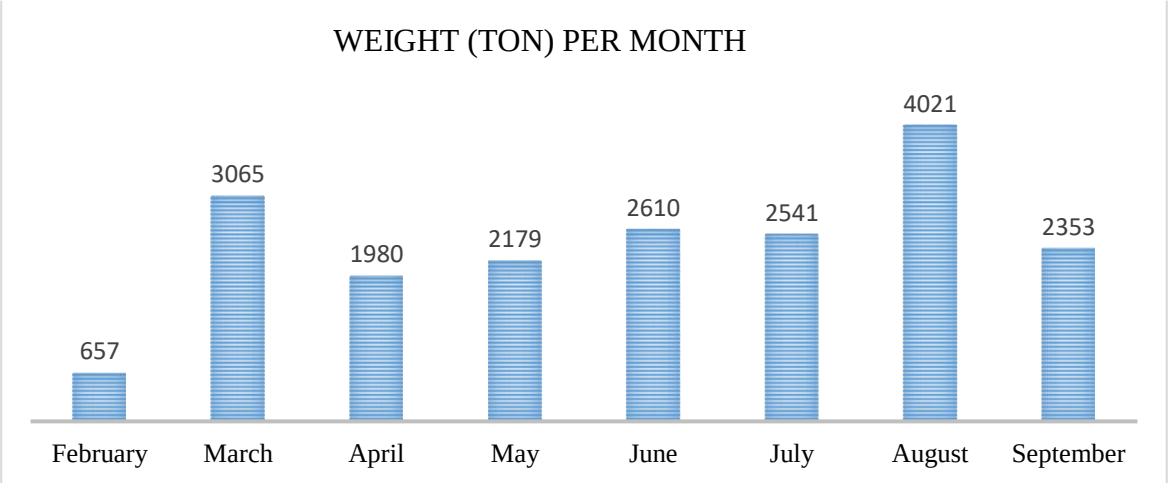

Figure 10. Comparison of solid waste generation at ward no. 6

4.6 Ward No. 6

Total area of ward no. 6 is 3.029 Sq. km and total number of holdings 1361 with area of Pollobi, extended Pollobi, New Pollobi section 7, Milkvita road, sujatnagar, horunabad, Mollika housing arambag, Arifabad, chaynir, section 06, Block C, Block D, Block E, Block T, Block Jha, Alundi duaripara, Rupnagar and Eastern Housing. There was a surge in generation recorded in March and August although rest of the months remain steady.

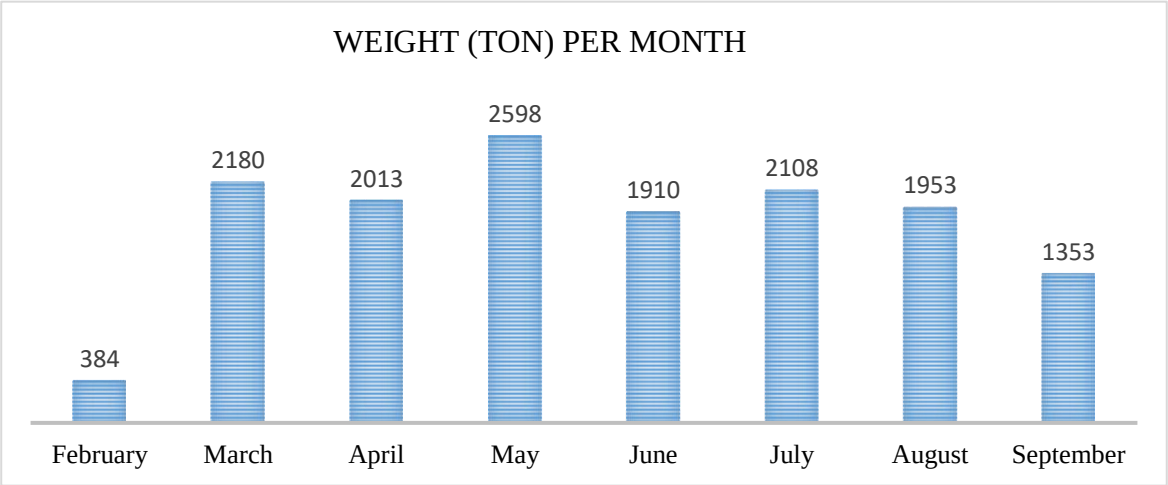

Figure 11. Comparison of solid waste generation at ward no. 7

4.7 Ward No. 7

In this ward, it has shown that a slight drop of generation in the month of September but the influencing fact remain unknown. Mirpur Section 7 Pallabi WAPDA Colony, Digun Senanibas (Cantonment), Albodi Rupnagar Tin Shed, Duari Para, Section 6, Block C, Block D, Block J, Block T is constituents. Total area of ward 07 is 3.029 Sq. km and total number of holdings 2981.

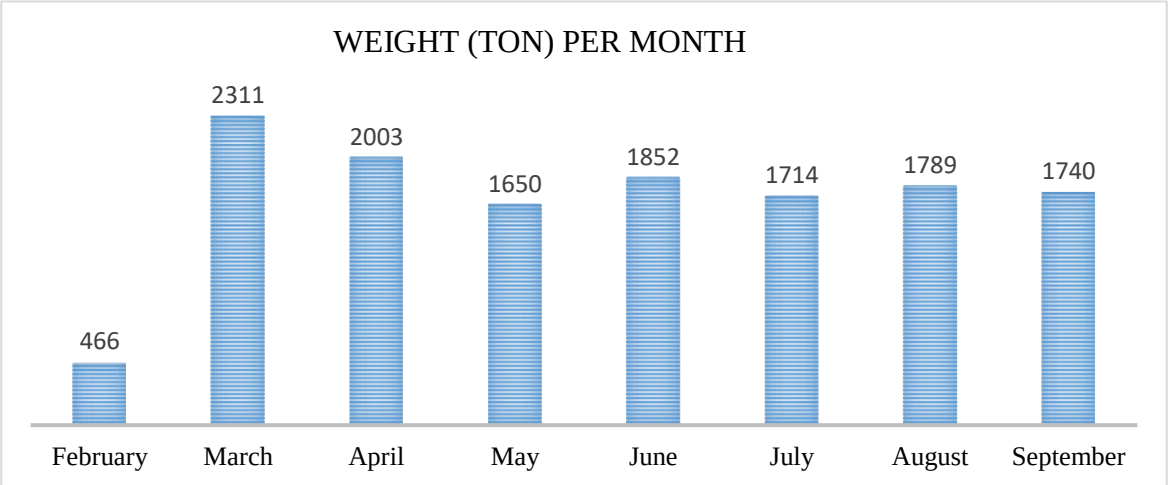

Figure 12. Comparison of solid waste generation at ward no. 8

4.8 Ward No. 8

It consist of Mirpur Section 1, North Bishil, Chiriakhana R/A (Box Nagar), Botanical Garden R/A, Nobaber Bagh, Chotbari, BISF Staff Quarter (Kumir Shah Mazar), Zoo residential area, Al kamal housing, Goran cotbari, Priyanka housing section 1 new C block, Wapda colony,Block A, Block B, Block C, Block D, Block E, Block F, Block G, Block H,

Business plot, Permanent house. Total area of 3.776 Sq. km and total number of holdings 3040. Almost similar trend was spotted in this ward.

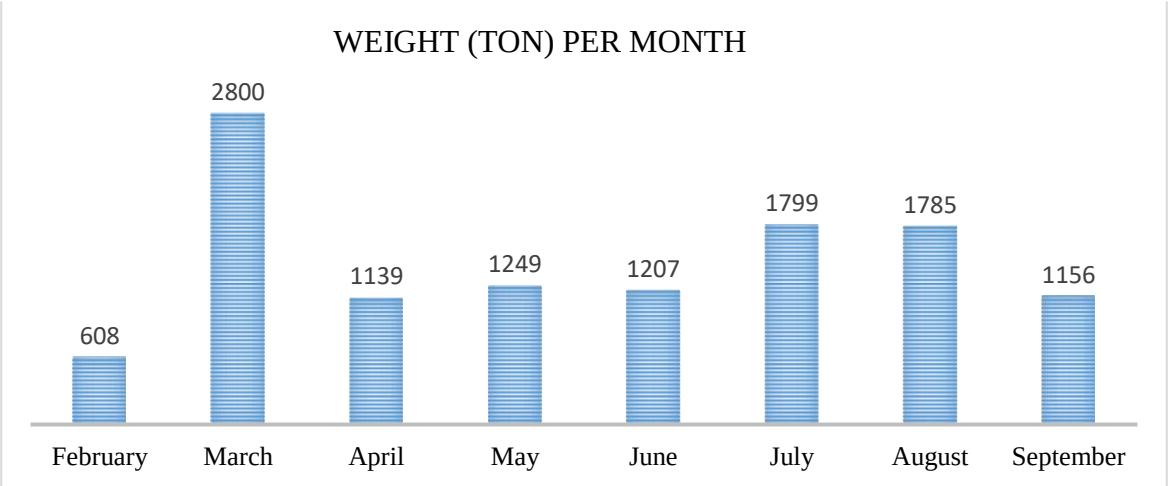

Figure 13. Comparison of solid waste generation at ward no. 9

4.9 Ward No. 9

At this ward area of Baghbari, Horirampur, Jahurabad, Bazar Para, Bardhanbari, Golartek, Choyadia Bari, Jahanabad, Kotbari, Anand Nagar were considered. Total area of 1.808 Sq. km and total number of holdings 4219. A rise of whopping 2800 ton recorded at the month of March. It was most likely to relate with ward no. 3 which shown similar pattern. It was worth mentioning that they both are situated in Mirpur Area.

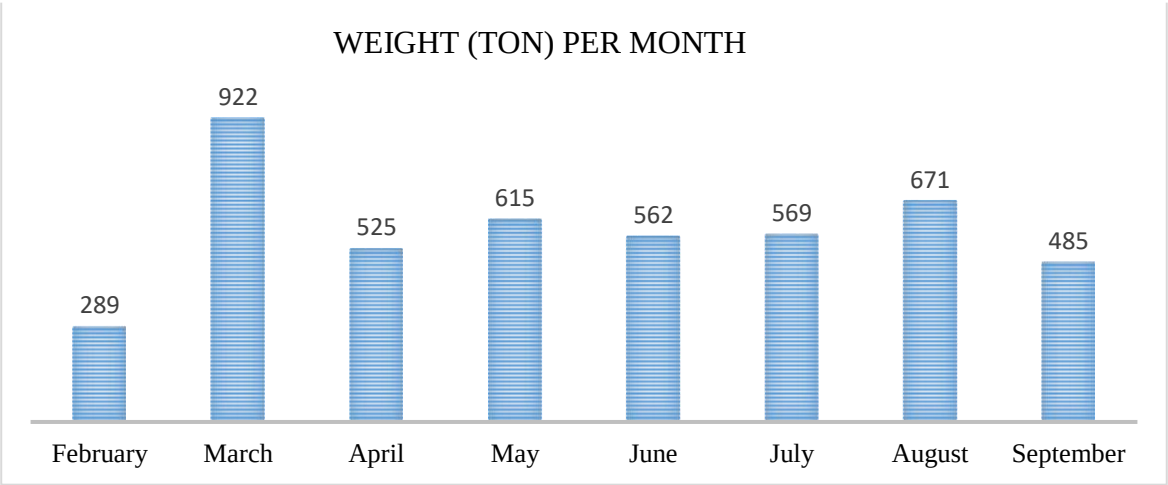

Figure 14. Comparison of solid waste generation at ward no. 10

4.10 Ward No. 10

In this ward a new and interesting information was found although ward no. 3 has the smallest area the rate of generation found lowest in ward no. 10 and that was just about half a ton above. The contributed area was Gabtali Jamidarbari (Hasnabad), Gabtali 1st, 2nd and 3rd Colony, Goidartek, Darus Salam and an area of 1.615 Sq. km and total number of holdings 2525.

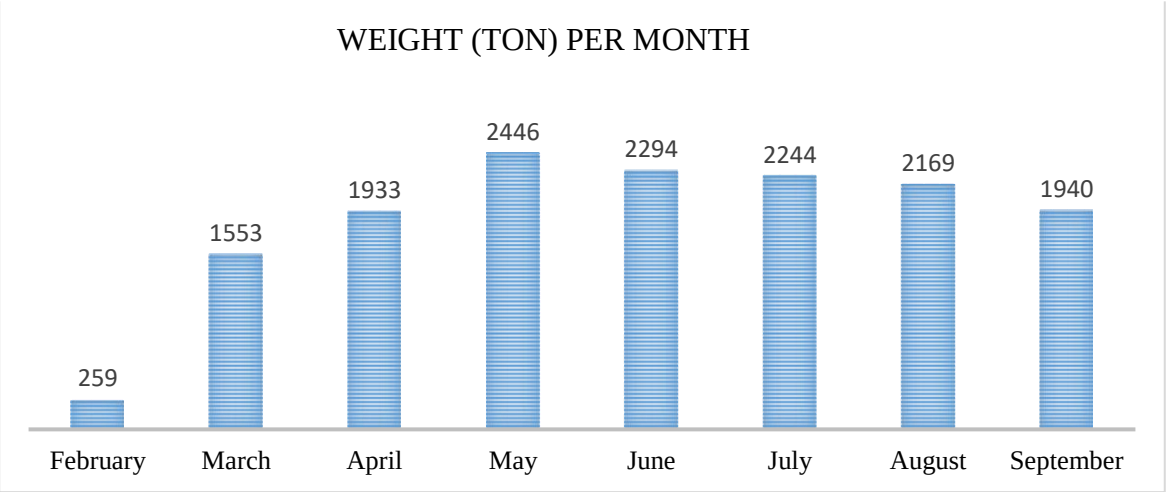

Figure 15. Comparison of solid waste generation at ward no. 11

4.11 Ward No. 11

Generation of waste steadily grown up to May and following same but falling pattern thereafter. Number of total holdings 3733 with area of 1.133 Sq. km has Kallyanpur, Paikpara, Middle paikpara, Darus Salam road (partial).

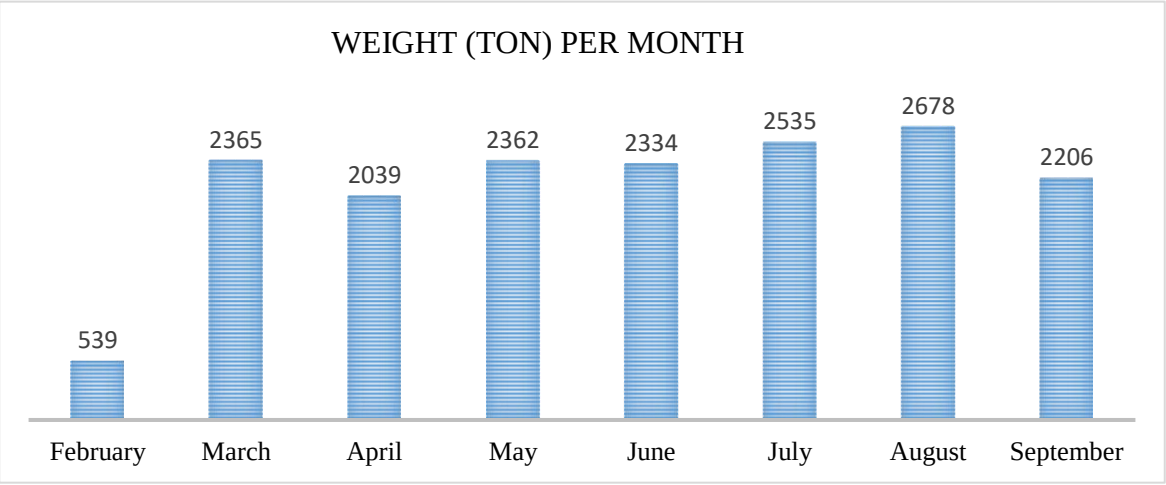

Figure 16. Comparison of solid waste generation at ward no. 12

4.12 Ward No. 12

In this ward nothing seen special to mention, all the month has a parallel rate of generation. Total area of ward no.12 is 1.697 Sq. km and the area belongs to Ahmed Nagar, South Bishil, Shahali Bagh, Kalwala Para, Paikpar Staff Quarter, Education Board Staff Quarter, WAKAP Colony, Tolarbagh, BADC Staff Quarter. There was a total Number of 3266 holdings.

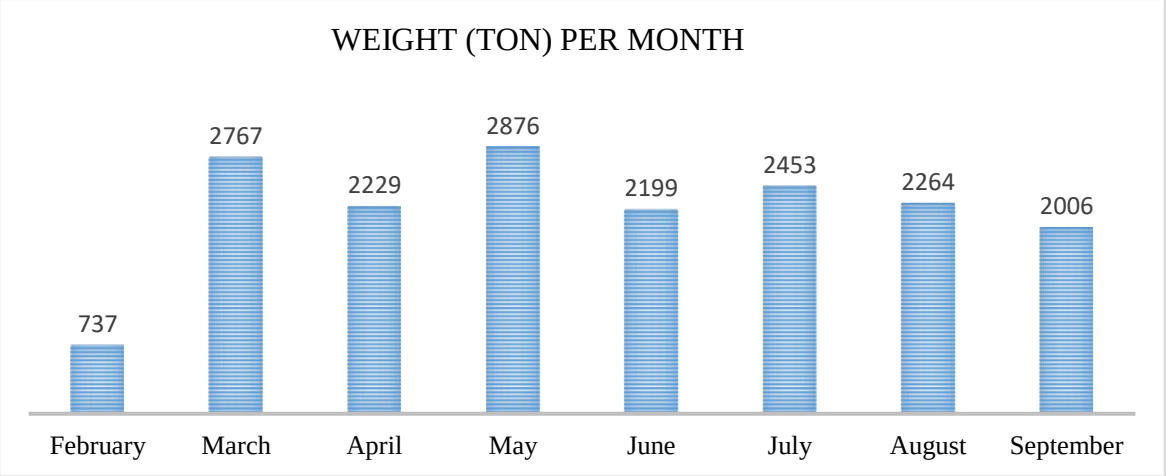

Figure 17. Comparison of solid waste generation at ward no. 13

4.13 Ward No. 13

March and May found a similarity in terms of generation all other has a close average rate. Consisting area is Bara Bagh, Pirerbagh (East, West, North, South), Monipur, Shewrapara (West and Middle). Total area of ward is 1.814 Sq. km and total number of holdings 4880.

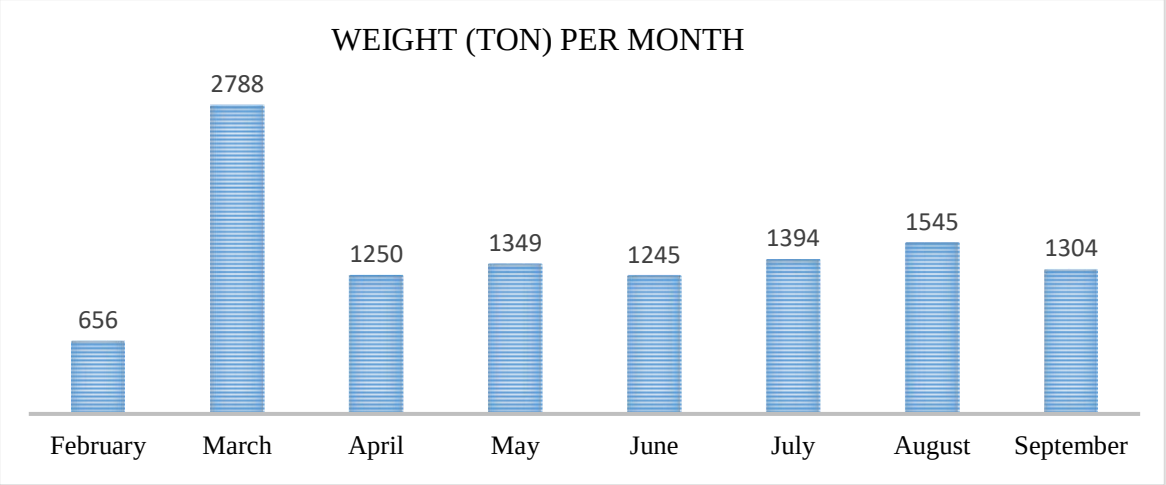

Figure 18. Comparison of solid waste generation at ward no. 14

4.14 Ward No. 14

At this ward it has seen a connection with ward no. 10 which also correlates with ward no. 3 to describe shortly all of wards has a highest March. Kaji Para (East and West), Shewra Para (East and West), Senpara Parbata, Rokeya shoroni, Mirpur road all contributes to the area with a total number of holdings 6907 and 1.947 Sq. km of area.

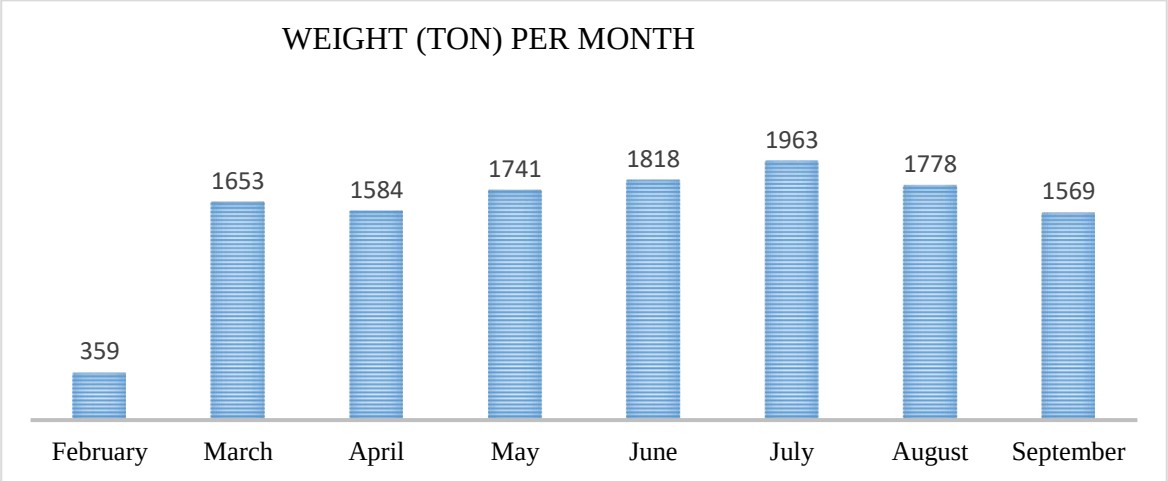

Figure 19. Comparison of solid waste generation at ward no. 15

4.15 Ward No. 15

An all indifferent pattern found which was following ward no. 7 Here in this ward Vashantek, Albodirtek, Damalkot, Lalasorai, Matikata, Manikdi, Balughat, Baigartek, Barontek located. Total area of 5.806 Sq. km and total number of holdings 3729.

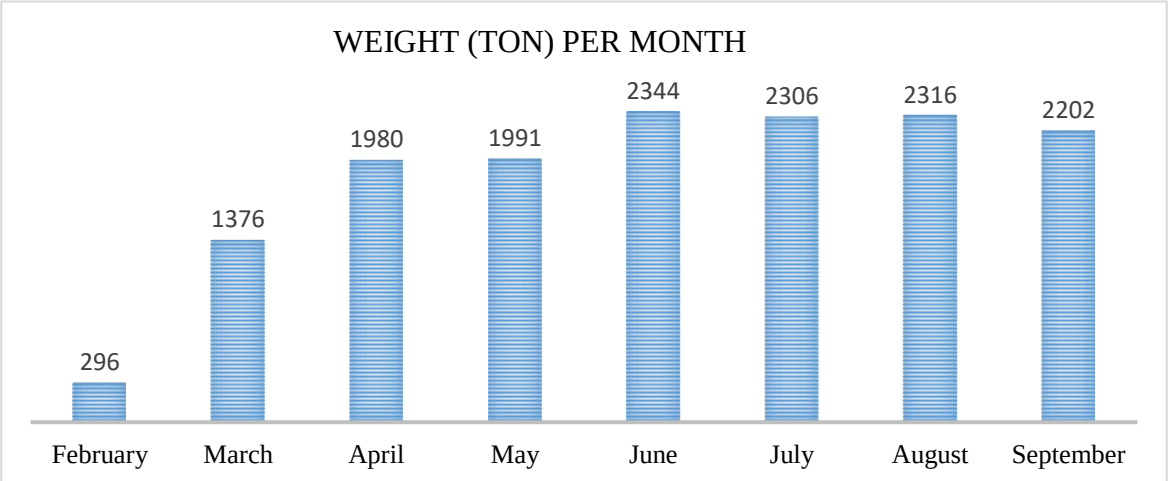

Figure 20. Comparison of solid waste generation at ward no. 16

4.16 Ward No. 16

Ward no. 16 which consist of Kafrul, North Kafrul, South kafrul, West Kafrul (Taltola), Ibrahimpur, Kochukhet road with Total area of 2.088 Sq. km and total number of holdings 4559. Although change was insignificant but in the March shares less when it compares with another months.

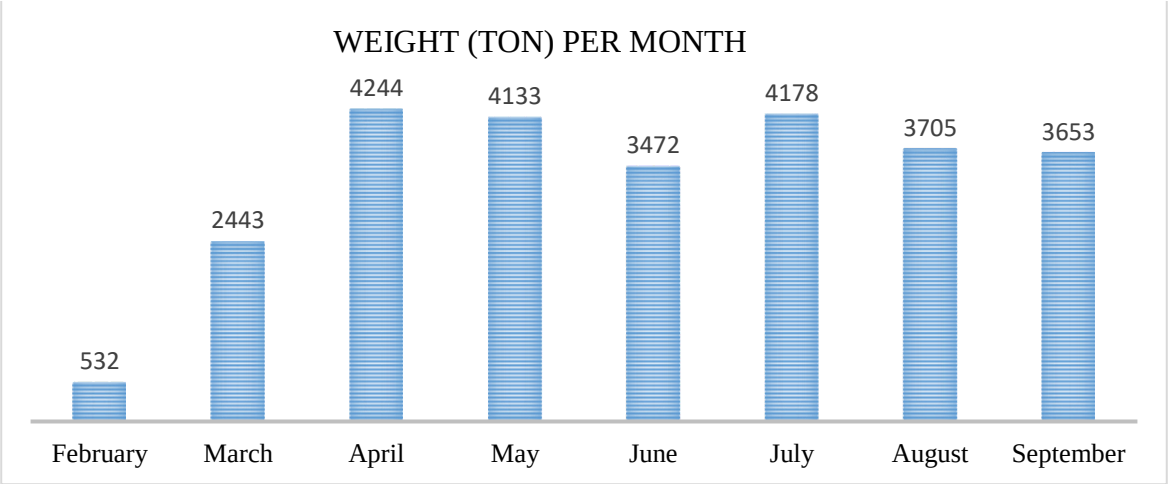

Figure 21. Comparison of solid waste generation at ward no. 17

4.17 Ward No. 17

Khilkhet, Kuril, Kuratoli, Joyarshahara, Olipara,(Partial), Jogonathpur, Nikunjo 1 and 2, Tanpara all are the constituents of the ward no. 17. A total area of 5.474 Sq. km and total number of holdings 5880.In this ward there was variation in rates among months though it was insignificant.

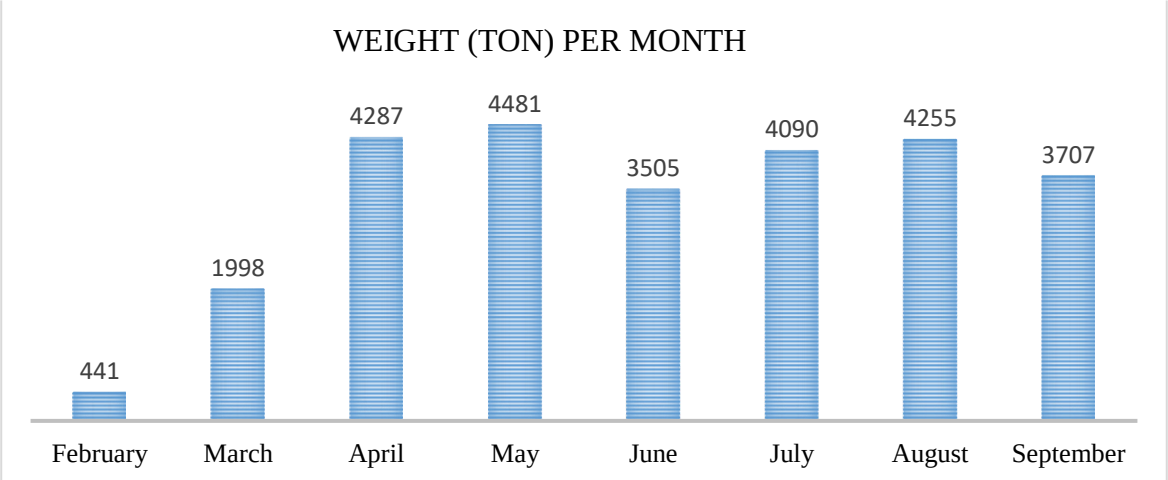

Figure 22. Comparison of solid waste generation at ward no. 18

4.18 Ward No. 18

At the ward no. 18 an area of Baridhara R/A, Block- I, K (as per Gazette 1980), Kala Chandpur, Nordda, Shahjahanpur (Ka, Kha, Ga) was located. There was a total number of holdings 3344 and area of 1.749 Sq. km This ward was following alike ward no. 17 by rate of generation or volume of waste. Even though their size was immensely different from each other.

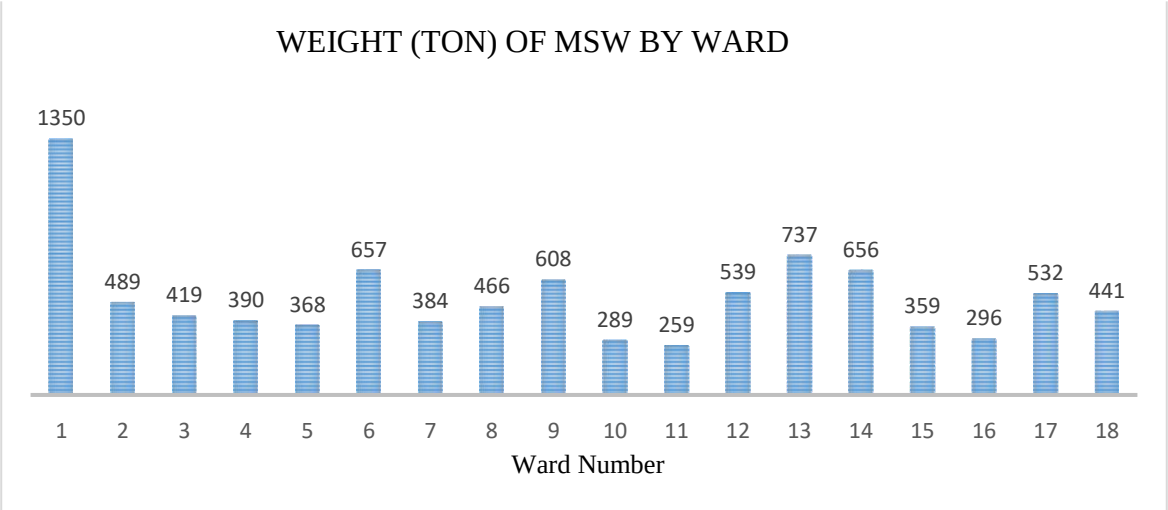

Figure 23. Weight of MSW by ward in the month of February

4.19 February

Since there was only last ten days of data available to proceed and sorting to represent, it was seen that word no. 1 reported to surpass all among others by nearly double. It should not be that significant because there was a limitation and unavailability of data. Hence there was not much accuracy for February month.

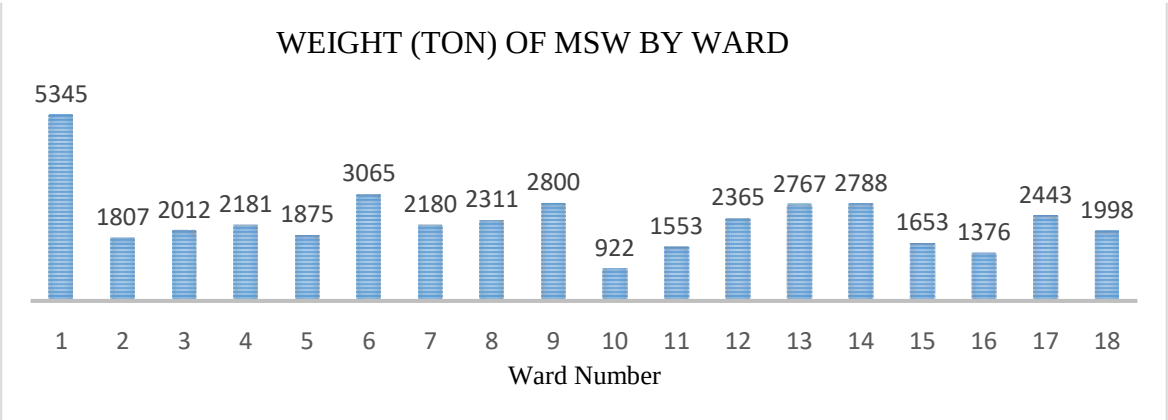

Figure 24. Weight of MSW by ward in the month of March

4.20 March

In the month of March, it been seen a high rate of waste generation in the ward no. 1 and all over the study it was remaining fact that ward no. 1 has largest rate of waste production among all other wards. This is a fact because of the size of the ward as well as number of holdings it already discussed earlier on 4.1. The lowest however is ward no. 10.

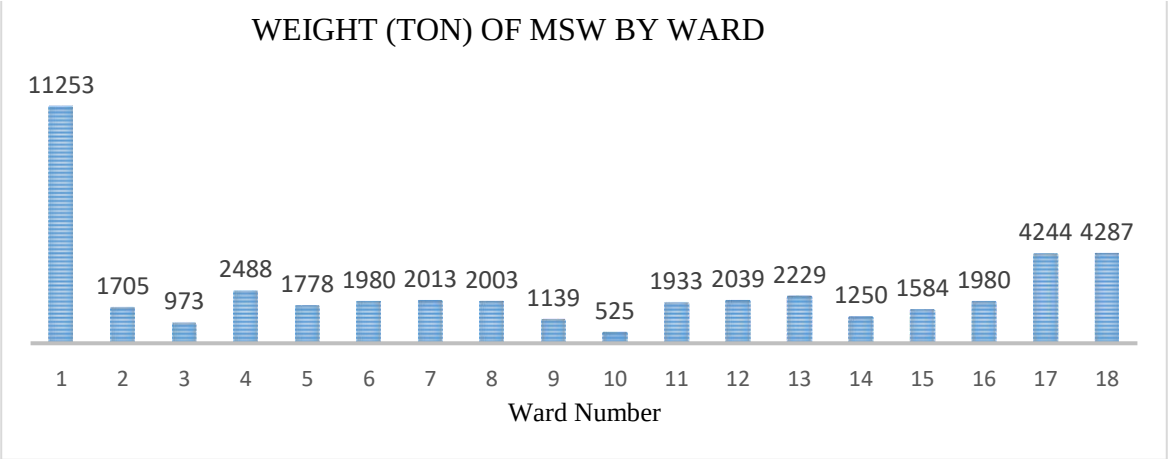

Figure 25. Weight of MSW by ward in the month of April

4.21 April

All throughout of the study shows that ward no. 10 has lowest contribution to landfill and behind the reason should be its area and number of holdings both are the less compared to other wards.

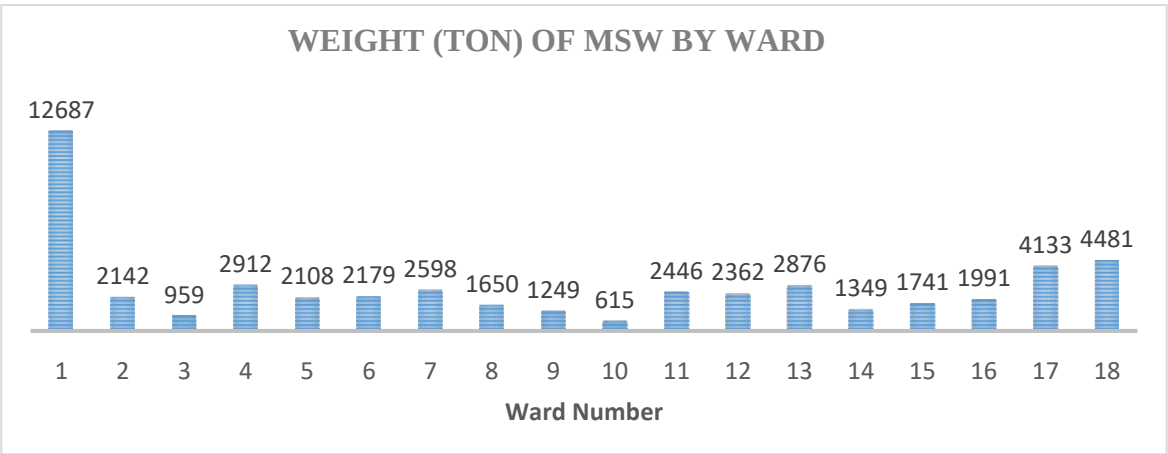

Figure 26. Weight of MSW by ward in the month of May

4.22 May

It was seen similar pattern as before ward no. 1 has highest and ward no. 10 has a lowest amount of generation. Ward no. 11 to 13 has a similarity in generation except March. Thus, it can be said that weather has an impact on pattern of generation of the waste.

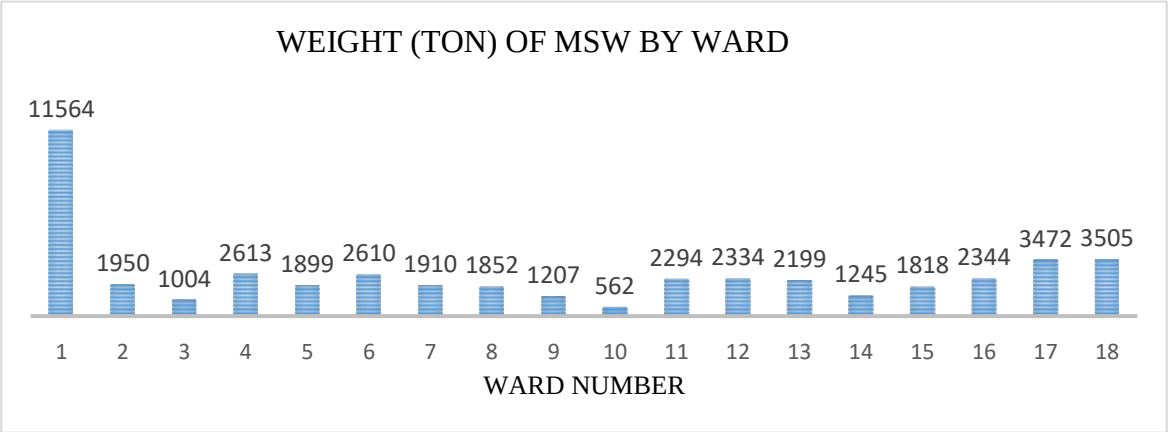

Figure 27. Weight of MSW by ward in the month of June

4.23 June

A reliable correlation was found which was with ward no. 17 and 18. Both of this ward has a similarity in generation of waste and contributes a significant number all over the season. It has seen that the rate of generation was the second highest after the ward no. 1 which is way higher compared to all other wards.

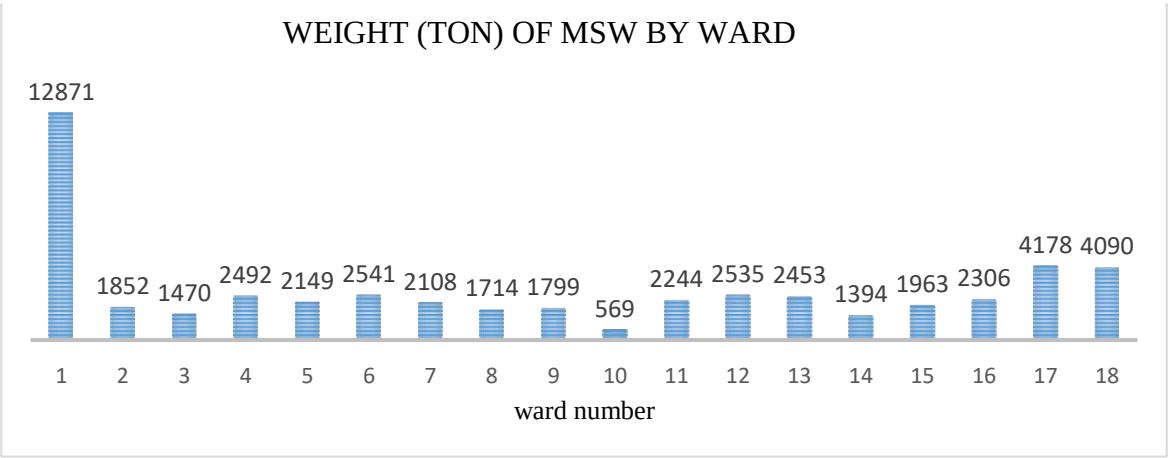

Figure 28. Weight of MSW by ward in the month of July

4.24 July

In July there was a similar pattern identified as it shown earlier that all throughout the study. The highest and the lowest remain same and ward no. 11 to 13 has a correlation as wall ward no. 17 and 18. All the other ward corelates but not so well among them and other months also.

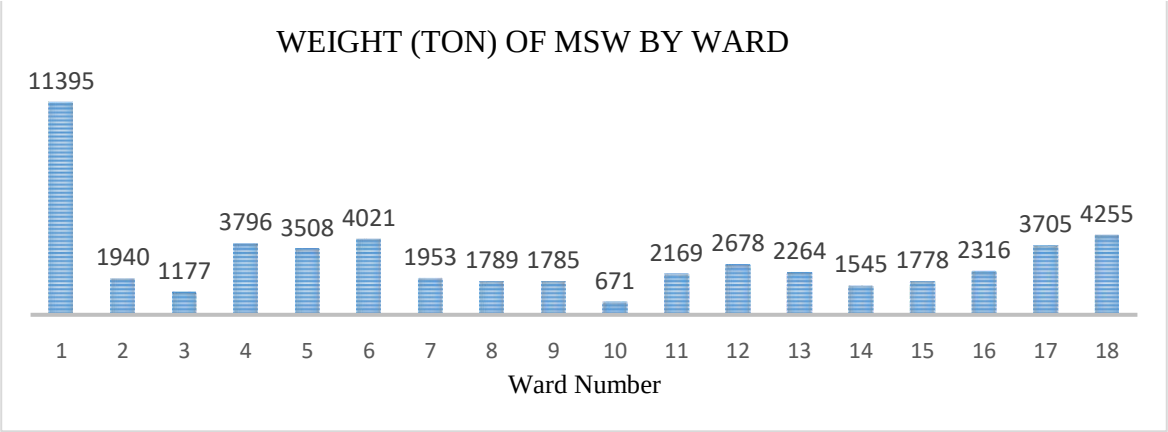

Figure 29. Weight of MSW by ward in the month of August

4.25 August

A discrepancy in ward no. 11 to 13 was showed although it was not so differing from each other but also not a matter to overlook since it has said that all have a correlation and it seen a very minimal variance. All the other described are remain same. A similarity in ward no. 4 to 6 was found for the month of August.

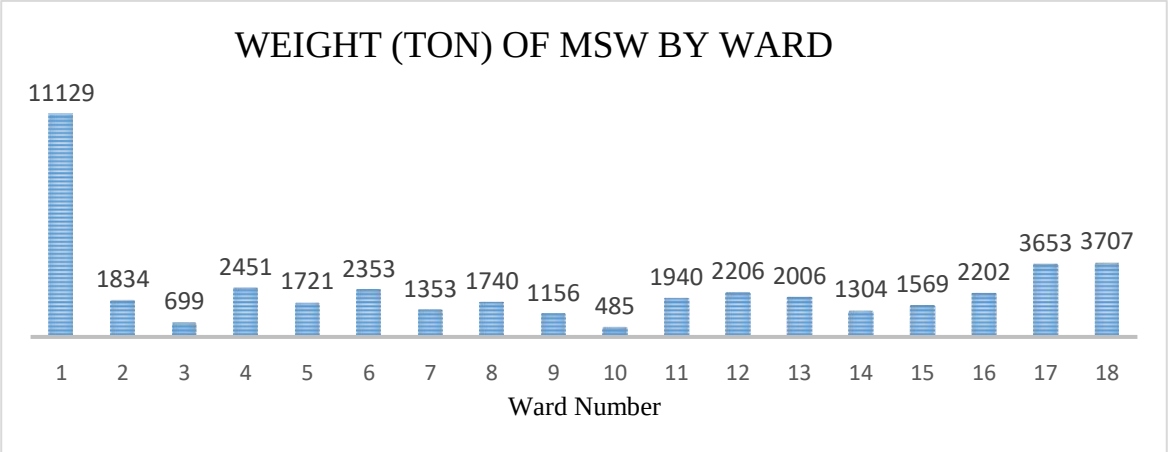

Figure 30. Weight of MSW by ward in the month of September

4.26 September

It can be shown that September has a correlation with prior month of August. Both of it has a similarity in the rate of generation and ward wise volume. It can be summarized by saying

that highest and lowest are the same and pattern like ward no. 17 and 18 also no different and finally ward no. 11 to 13 and 4 to 6 has a similarity.

Chapter 5

Conclusion

This work was unique in its kind and takes noticeable efforts to accomplish. A correlation of waste generation was found and matches among months and highest and least also remains same. A change due to dry and wet weather condition also traced on February and March ward no. 6,13 and 14 tend to be higher in volume whereas ward no. 17 and 18 found leading for wet month from April up to September. Both correlation and contradiction were observed while performing analysis among wards. An influx in volume of waste was spotted which was the highest amount of waste generated at ward no. 1 because of the underlying areas where mixed use of residential and commercial zone was established. It was also found that the area was largest among all other ward along with number of holdings it belongs to. However, the least rate of waste generation was identified by ward number 10. This study also found ward no. 1, 11, 16, 17 and 18 all similar in terms of rate of generation in the month of March which nearly half the rate from other months. Although different patterns were formed by ward no. 3, 9, 10 and 14 where in March declined by half from others. This study largely supports the fact of lower rate of generation because all constituents ward is highly densely populated which supports the overall fact of the city and better represents the city. However, slightly different influence found for the ward no. 4, 5 and 6 because all of them show higher volume in August. Most similar pattern was observed in ward no. 2, 8, 12 and 15 all of them are analogous for longer time whereas ubiquitously disobeying pattern found in the ward no. 7 and 13. A year-round analysis of data could help more to determine the success of the study but since there was a time constraint which bounds the further proceedings. Additionally, Numerous factors should consider for tangible outcome of the study. For instance, precipitation, time, temperature, humidity, exposure of waste to sunlight, method of waste collection, composition of waste, behavior of residents, socioeconomic condition of residents, land use patterns, availability of other utility services etc. The authors of this thesis strongly recommend further studies in this field. Thus, a more specific analysis can be better performed, and further study should be conducted by using data science and more sophisticated software program should be incorporated like SQL and R. This type of study will give an insight to the authority but has impertinence to know the rate of waste it generates at any given time. Especially it can help the authority to make informed decision by knowing ward specific waste generation and to design efficient means of waste management because data cannot mislead and less prone to error.

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