FOOD "WASTE" – AN UNTOUCHED GOLDMINE

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Declaration

I hereby declare that this dissertation titled Food “Waste”- An Untouched Goldmine is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

Ishan Dwivedi

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List of Abbreviations

CE- Circular Economy

OFW- Organic Food Waste

Kg- Kilogram

MT- Metric Tons

EU- European Union

Municipal Solid Waste- MSW

Nitrogen- N

Phosphate- P

Potassium- K

Greenhouse gas- GHG

Carbon Credit- CC

Global Warming Potential- GWP

Abstract

In the past, most of the studies revolved around the reduction and reuse of the organic waste in the consumption chain. But here in this study, the whole process chain's economic and environmental monetary values will be investigated to convert organic food waste (OFW) into compost, following the Circular Economy (CE) indicators. Just for an instance, in the Food Waste Index Report 2021 by UNEP- India is mentioned to have food waste up to 68,760,163 Tonnes per year. Over 250 of the 500 Fortune companies are located in the city Gurgaon and rapid growth has contributed significantly to the population and pollution rise. Realizing the seriousness of the problem, the city is making efforts for adopting feasible practices and technologies for sustainable solid waste management.

This is where **Balancing Bits** which is empanelled with Municipal Corporation of Gurgaon comes into picture, they have 30+ project footprints in Gurgaon - NCR region and offer as a waste management solution for societies and corporates as well. Discussing in detail process and revenue systems with the Founder of **Balancing Bits – Rahul Khera** and observations of the process/technology used in the compost plant we have recommended few solutions by which Indian government can earn a revenue of 400 -500 Crore Rupees only from managing food waste properly and can lower down the pollution rates happening because of Dumpsites and reclaiming the land area for proper commercial use, by simply implementing various technologies already available in the market.

The UN has reported that the value of food wastage in India is around ₹92,000 crores per annum. At present, in India - an individual is still not

aware about organic waste management or food waste management whereas on the other hand Indian Government is only making aware of how to manage or not to use plastics and that's too in dilemma. In this study, we shall discuss more about the city- Gurgaon, where there are Society based committees- Resident Welfare Associations (RWAs) are formed therefore, a proactive approach is taken to follow the compliance rules dictated by Municipal Corporation of Gurgaon (MCG) -byelaws, after the enaction of Solid Waste Management Rules (2016) by The Union Ministry of Environment, Forests and Climate Change (MoEF&CC).

The current estimations are that the population of Gurugram is close to 2.5 million and is expected to grow to 4.3 million by 2031 as per Gurugram Master Plan 2031. This has also led to an unplanned development over the years in past which resulted in tremendous increase in the waste being generated. As per MCG, it was about 400 MT in 2009, 600 MT in 2015 and was 750 MT daily in 2017. The projected solid waste generation in 2041 for Gurugram is expected to be about 2900 MT (3197000 kilograms) per day.

Keywords: *Gurugram, Food Waste, Compost, Landfills, Greenhouse Gas, Municipal Solid Waste, Circular Economy, Carbon Credit, Waste Management, Sustainable Revenue Streams, SWM Rules 2016*

Background & Literature Review

According to a field survey carried out by MCG in September 2015, about 71% (2269870 kilograms- 2300 Tonnes- per day) is kitchen waste and the rest being is non-biodegradable and inert in nature *(Dr. BP Naveen, 2018).* If calculated for a month, it results 71300000 Kilos (71300 Tonne) food waste and 855600000 Kilos (855600 Tonne) food waste for a year. Focusing on increase in population year by year food wastes will only be in the upward trend.

This massive quantity of OFW (Organic Food Waste) can produce ranging from (taken 10% to 30% of convertible organic waste into compost) *(Agency, 2022)* 85560 to 256680 tonnes of compost in a single year which has the potential to result in dramatic reductions in greenhouse gases (CH4 emissions), decreasing the height of dumpsites, reclaiming landfill area and last but not the least better employment opportunities in the field of waste management sector. The implementation of various traditional technologies in converting this organic waste will generate net revenue of 343 Crore Rupees for a year (taken average of 40 rupees per kilogram) *(Big Basket, 2022)* - only from compost selling along with a potential substitute of various kinds of chemical fertilisers following the Circular Economy. If calculated including inflation rates and year by year increase in food waste then this amount can range nearly from 400 to 500 Crores in the upcoming years which seems small amount of money but can help many lives and generate new green jobs in the waste management sector, to be specific this amount is only being counted for Gurugram City. The environmental savings, waste dumping and carbon crediting related to CH4 reduction can be dramatically reduced. In general, implementing the composting technology following the CE model has the potential to add a cumulative net revenue of 10-12 Lakh Crores to the national economy of India alone from organic waste (taken 4000 cities and multiplied by 300) *(Non Residents Indian Online, 2022)*. Implementing the Circular Economy model in Organic Food Waste generating compost, reduces waste management problems by closing the materials recycling loop, generating extra income, and adds net revenue to the national economy. It will also help the decision-makers to amend our existing SWM Rules into a suitable sustainable waste management policy.

Waste is not a waste, but a Goldmine not mined. This is what study tries to prove with approachable estimations and implementable solutions in the country.

Gurugram shares its boundary with Rajasthan state and southern part of Delhi state making it a strategically located city at about 30 Km from Delhi. It is one of the four suburbs of the National Capital Region of Delhi. It is the second largest city in Haryana. As stated earlier, it is also called the Millennium City with its vast array of commercial malls, cyber parks, hi-tech offices, and plus residential buildings. The present area of Gurugram city is 231 square km and it is divided into 35 municipal wards. It has 37 urbanized villages in its fold. Gurugram city lies on the northern fringes of the Aravalli Mountain ranges which are the oldest ranges in India. *(Government of Haryana, 2022)*

The circular economy (CE) is a notion that supports the responsible circularity of the available resources to attain sustainable development goals. This concept involves a regenerative model where efforts are made to minimize the inputs and waste in any form of leakage or disposal to close or slow down the materials loop. The implementation of this approach is thought to reduce the environmental burdens of

global warming and resource scarcity caused by the industrial revolution.

Most industrial enterprises and businesses follow linear economy concepts worldwide. The products manufactured in the industry are taken for utilization by the public and disposed of the unused, thus following the "use & throw" consumption model. Such practice is not in line with sustainable development goals; therefore, most of the countries around the globe are starting to implement CE in their national policies. And the best example was SWM Rules 2016 by The Union Ministry of Environment, Forests and Climate Change (MoEF&CC) *(Down To Earth, 2022)*. For instance, food waste can be utilized for compost (organic fertilizer) production, bioenergy, and several other value-added products.

Recent studies showed a slight shift from the current linear or moderate recycling model to better circular use of the materials which under normal circumstances treated as waste. The leading causes for the hindrance of circularity under waste management are economic, socio-cultural, and institutional factors. The main focus of most CE studies revolves around reducing, recycling, and reusing the material along the production and consumption chain and that's what we should be doing as a responsible citizen should pursue.

In India, food waste is the mainstream of municipal solid waste. Recent estimates suggested that this waste was up to 71% of the MSW in the city of Gurugram. *(Naveen, 2018)* Food waste is generally mixed with MSW and disposed of in Dumpsites without being processed for any material or energy recovery from this precious organic source. Such management practices are a source of pollution to water bodies and the atmosphere. About 40% - 60% methane gas is emitted from landfills, causing severe environmental issues only because of organic food waste. *(Agency for Toxic Substances & Disease Registry, 2001)*

In the future, following the linear economic model, this current waste management, based on the notion of “use & throw” is absolutely not working in the region. To cope up with these waste management-related environmental issues and decrease its dependence on the chemical fertilizers and fossil fuels, the government of India has launched a set of rules known as SWM Rules (2016). Seeking sustainable solutions, to manage huge waste production and minimizing its disposal to Dumpsites for the generation of economic benefits is among the key objectives of these rules. To comply with this vision in food waste management, CE would be the best strategy to adopt. Waste can be minimized, reused, or recycled in production and consumption chains by applying CE indicators utilizing the Circular Loop Approach.

This study includes compost production from OFW and estimating how much savings can be achieved. The conversion of food waste into compost and its application in agriculture as the end product would be the first step towards transitioning the linear model of the economy to a circular one by closing the material loop without producing any other side product or so-called waste material. The process will follow cleaner production principles to achieve sustainable waste management goals for promoting CE in this sector.

This study's main aim is to investigate economic, environmental impact assessment and quantitative analysis of compost production potential from food waste produced in Gurugram city. This analysis includes the conversion of food waste to compost as the starting material. The tipping fee saving by diverting food waste from the landfill. Carbon credit-earnings equivalent to the GHG emission savings by avoiding landfill dumping. The revenue obtained by selling fertilizer and its application to the soil to enrich macronutrients, i.e., C and NPK (Nitrogen, Phosphate and Potassium).

Landfills

In India, according to Municipal Solid Waste (Management and Handling) Rules, 2000- it is mandatory to use sound and sustainable practices for management of MSW. These rules have been divided into four Schedules, I-IV. *(Central Pollution Control Board, 2000)*

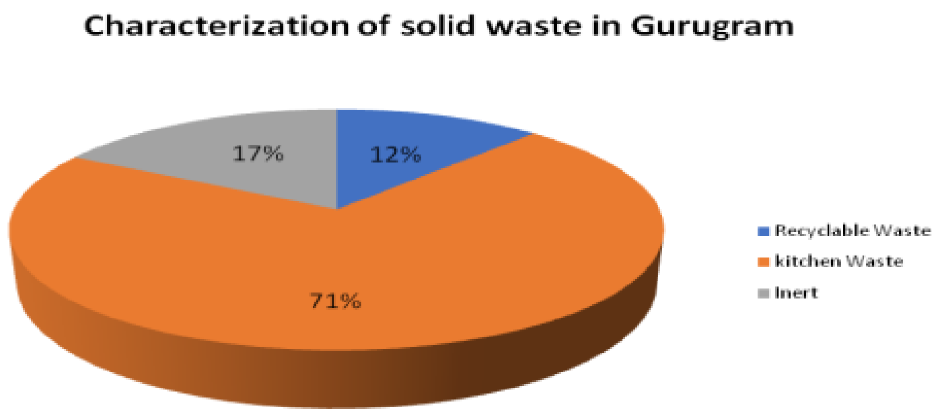
- The Schedule I has the Implementation schedule for setting up landfill areas,
- Schedule II is about the improved techniques for the management of MSW,
- Schedule III is about specification for the MSW landfill sites-layering, capturing of GHG's, collection of leachates etc.
- Schedule IV is about the MSW compost standards, treated leachates and Incineration of MSW. But still compliance to these rules is not evident.

Globally too, landfill has been used for many years as a most economic method of refuse disposal. The organic component in landfill municipal refuse results in GHG emission via microbial decomposition by anaerobic condition. The average composition of landfill gases is 50% methane and 45% carbon dioxide, 5% Nitrogen gas, <1% hydrogen sulphide and other non-methane organic compounds (NMOCs). *(The Role of Bioenergy in the Bioeconomy, 2019)*

Due to an increase in population and subsequently increase in waste generation, landfills could become a major source of atmospheric methane. Global methane emissions from landfill are estimated to increase more than 30 million tons every year. Most of this landfill methane currently comes from organic waste, where the levels of food waste generation are on the rise. Generally, 50% of carbon emissions in the landfills are transformed into methane. It has been reported and confirmed that 13% of landfill emission of methane is emitted from municipal solid waste landfills in the world. *(Singh, 2018)* In India, the MSW management (collection, storage, transportation, processing, and disposal) is generally done by municipal authorities in cities and by local bodies in rural areas. The MSW management scenario is more severe in Indian metro cities, where with large population growth, MSW generation rate is increasing but waste management strategies are not in pace with it. Like any other country, in India too landfill remains the most popular method of disposal of MSW as landfill is more economical way of disposal of waste. The present scenario is such that landfills in metro cities have been used for almost 15-20 years and there is big mountain of MSW in it (for example - Bandhwari on the outskirts of Faridabad and Gurugram and Bhalswa, Okhla and Ghazipur Dumpsites in Delhi) *(The Hindu, 2019)*. Scarcity of land in the cities and awareness among the citizens made it difficult to find new landfill sites. At present, Environmental Impact Assessment (EIA) has become compulsory to construct any waste processing and landfill area in India. Therefore, the planned landfill sites, methane gas utilization and reusing material has made compulsory in India.

At present, the GHG emission from insecure landfills remains the big issue for MSW management in India. Landfill gas release represents physical (explosion), chemical (substances in ambient or indoor air or odour), and quality of life public health concerns for those who live near or work in landfill. Indiscriminate land filling leads to deterioration of water quality in neighbourhood areas. This has adverse health impacts on people living nearby landfill and they are in the constant fear of explosion of accumulated methane gas. The methane gas utilization as an energy resource is not well studied and practiced in India. Whereas large number of studies are available in western countries on landfill gas utilization as renewable energy source. The GHG emission from landfill areas in India has come into focus in last two decades and there is more number of studies on methane emission from landfill areas. *(Singh, 2018)*

Methane is produced in large quantity in landfills, as a consequence of the degradation of organic matter under anaerobic conditions. Landfills often accept waste over a 20 - 30 years period, so waste in a landfill may be undergoing several phases of decomposition. *(Ramanathan, 2011)* This means that older waste in one area might be in a different phase of decomposition than more recently buried waste in another area. It escapes from landfills either directly to the atmosphere or by diffusion through the cover soil. And whole problem starts with not managing our food waste properly.



It is presumed that the Municipal Solid Waste composition consisting of Organic Food Waste in Gurugram, constitutes 71% of the overall annual MSW. In a business-as-usual scenario, the MSW is dumped in the landfill without any material or energy recovery. The composting technology's organic fertilizer (compost) production potential is calculated by considering a 10% to 30% compost production yield with 40% moisture content. *(Sayara, 2020)*

Carbon Credits

In today's scenario Global Warming is costing a lot of money, so Green Environmentalist aimed to promote policy and business that works for the environment. As we all know, carbon dioxide, the most important greenhouse gas produced by combustion of fuels, has become a cause of global panic as its concentration in the Earth's atmosphere has been rising alarmingly. This has created an opportunity for the trade of carbon credits both within and outside of the regulated area, thereby creating a global "carbon market". In this system of carbon trading, controls are imposed on Greenhouse Gas (GHG) emissions under the Kyoto Protocol, and the pre-decided emission limits are then allocated across countries, which have to control the greenhouse gas emissions from the various industries and commercial units operating within them.

The Kyoto Protocol was initiated by the United Nations Framework Convention on Climate Change and ratified by 181 countries and the European Union as a whole, individual entity in 1997, and was put into effect in 2005. This protocol was proposed by the international community to address and reduce greenhouse gas emissions that have led to global climate change. The Protocol makes it mandatory for commercial entities emitting above the permitted limit of carbon dioxide to cut down their emissions to prescribed levels, or they should buy carbon credits certificates which can be transacted in the market, or alternatively pay a charge for the emissions, which is referred to as carbon tax. *(Gupta, 2011)*

Instruments like carbon credits and carbon offset were introduced in order to improve the scenario by encouraging firms to be more environment friendly in conducting their business. One carbon credit allows one tonne of carbon dioxide or a corresponding amount of other greenhouse gases to be discharged in the air. Businesses that are over their quotas must buy carbon credits for excess emissions, while those below can sell their remaining credits. This exchange of credits between businesses has encouraged carbon trading globally. These credits can be exchanged between businesses or bought and sold in international markets at prevailing market price at two exchanges, namely the Chicago Climate Exchange and the European Climate Exchange. *(Wikipedia, 2003)* The amount of global emissions can be controlled through the buying and selling of carbon credits in the carbon trading method. It is quite simple and convenient to purchase Carbon Credits from several firms, just like any other monetary instrument, as they are traded in an open market.

Carbon trading is used when the company's emissions exceed its quota of carbon credits, forcing it to purchase credits from other companies which have spare carbon credits. As a result, the worldwide carbon emissions stay within permissible levels, and the companies come up with ecologically sustainable ways of conducting business. The system also motivates the organisations to be more eco-friendly so that they can increase their earnings by selling carbon credits. As carbon credits are freely traded in the market, they make it very easy for businesses to follow the system. There are no complex rules or procedures to adhere to, which enhances their acceptance and makes the system highly successful.

Carbon credits can also be purchased even if you are not a part of any organisation in order to lower your own carbon footprint. *(COSTAGLIOLA, 2021)* The money that you put in this manner is routed to fund ecological projects in any region on the planet so that the emissions made as a result of your activities can be neutralized. This sale and purchase in carbon credits helps limit the unchecked emissions of greenhouse gases throughout the world. Organizations responsible for atmospheric pollution are made to pay for their acts while ones taking positive steps are rewarded. In the present scenario, the market of carbon credits has a direct impact on the firm's financial analysis. This has caused firms to actively seek ways to decrease their emissions and adopt cleaner ways of doing business. Thus, the whole system motivates companies and governments to promote environment friendly processes that reduce greenhouse gas emission.

India is emerging as a serious player in the global carbon credits market. *(Singh S. C., 2022)* This has prompted originator, developer, and trader of carbon credits, to set up office in India. Carbon credit is very emerging domain now a days especially in India but very few corporates are aware of this emerging segment. At present it is quite essential to create awareness about this business segment. As India's GHG emission is below the target and so, it is entitled to sell surplus credits to developed countries. India is considered to claim about 31% of the total world carbon trade. *(PEDA, 2022)* This is what makes trading in carbon credits such a great business opportunity. Foreign companies which cannot fulfil the norms can buy the surplus credit from companies in other countries.

India has emerged as the dark horse in this race as more than 200 Indian entities have applied for registering their CDM Project for availing carbon credits. The 800 million farming community in India has also a unique opportunity where they can sell Carbon Credits to developed nations. The India's Delhi Metro Rail Corporation (DMRC) has become the first rail project in the world to earn carbon credits because of using regenerative braking system in its rolling stock. *(Hindustan Times, 2021)* DMRC has earned the carbon credits by using regenerative braking system in its trains that reduces 30% electricity consumption. It is believed that it is not the penalty awarded to erring companies, but the rewards and recognition given to green firms is what makes this system so popular and exclusive.

This means that companies with limited emissions will devise strategies to further reduce emissions so that they can sell more carbon credits in the international market and thereby increase their profits. Thus, the system keeps on de-polluting the environment increasingly.

In addition to this, the environmental savings includes dumping/tipping fees and carbon credits. The dumping fee is the amount of money paid to the waste disposal site for waste transportation and dumping. The dumping fee in Gurugram is 1000 Rupees/MT, *(Haryana Assembly, 2021)* this will be considered to calculate additional savings due to the waste diversion from the disposal site to the composting facility. The approximation of the carbon credit value for the waste is dependent on the methane/carbon emissions potential. At present in June 2022 – 1 Carbon credit holds the price of $3 (approx. ₹ 234.75*). (Indian Carbon, 2022)* The methane emission potential of the OFW fraction is computed by using the method endorsed by their partner **VNVadvisory**.

A global warming potential (GWP) of CH4 emissions in CO2 equivalents (CO2eq.) Mt, over 100 years, is calculated using a factor of 25. *(EPA, 2022)* However here in the upcoming years, the carbon credit (CC) value is estimated considering US$ 23.20 (equivalent to 1,808.47 Rupees CO2 eq.) The CC trading is possible at a web platform named GoldStandard.org- the estimated saving value represents the amount of additional revenue generation in executing the carbon trading system in India in each and every sector. The estimation of fertilizer savings is calculated by considering four essential nutrients, namely carbon (C), nitrogen (N), phosphate (P), and potassium (K). Generally, these nutrients are delivered to the crops through commercial fertilizer application. The alternate sources for the provision of these nutrients are simply an organic compost. It is assumed that mature compost contains about 40 % moisture content and 60 % compost dry matter (DM). *(Carry On Composting, 2022)* The selected nutrients reported values are 21.02 % for Carbon, 0.935 % for Nitrogen, 0.235 % for Phosphate, and 0.32 % for Potassium. The alternate C provision source humus contains about 24.18 % C content with a market price of about ₹40/Kg. The inorganic source of N provision to the crops is urea, which contains 46.6 % N content. The market price for urea is about ₹5.5/kg. Typically, P is provided in the form of DAP containing 46 % P content as P2O5. The cost of DAP is about ₹23.6/kg. The SOP is usually utilized as an additional source of K to the crops. It contains about 46% of K content with a market price of about ₹38/Kg. *(Google, 2022)*

The methane emission potential of the OFW fraction is computed by using the method endorsed by the Intergovernmental Panel on Climate Change. The mathematical equation for the specified is given in equation proposed by Balancing Bits' Partner – VNVAdvisory which is kind of out syllabus for a normal person.

The gross revenue is the sum of income arising from environmental savings including carbon credit value, tipping fee and compost selling, and cumulative fertilizer savings due to the application of compost as an organic fertilizer. The net revenue value is obtained by subtracting the composting facility's operational and maintenance (O&M) cost. The O&M cost is considered 30 % of the revenue generated by compost selling. The O&M cost included the waste collection, transportation, and O&M, and maintenance of the composting unit.

The steps followed in the revenue estimation are given in equations-

Gross revenue = Environmental savings (dumping fee saving + carbon credit value) + compost selling + cumulative fertilizer savings

Net revenue = Gross revenue – Operation and maintenance cost (waste collection + Operation and maintenance cost of the composting facility)

Technology

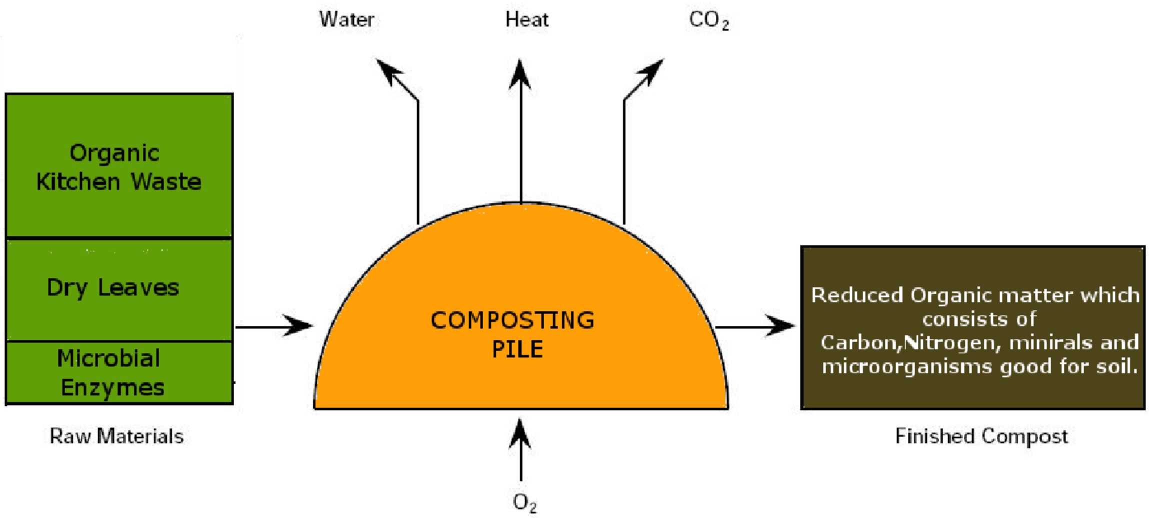
The composting technique used in the Balancing Bits is known as Aerobic hot composting.

Aerobic Composting is a natural process where bacteria, in the presence of air (oxygen) breaks down the organic matter through their metabolic activities and change organic wastes into valuable humus-like materials and minerals commonly called “compost”.

This is a form of accelerated aerobic composting that yields finished compost in 4-5 weeks.

The technology provides certain additional advantages like

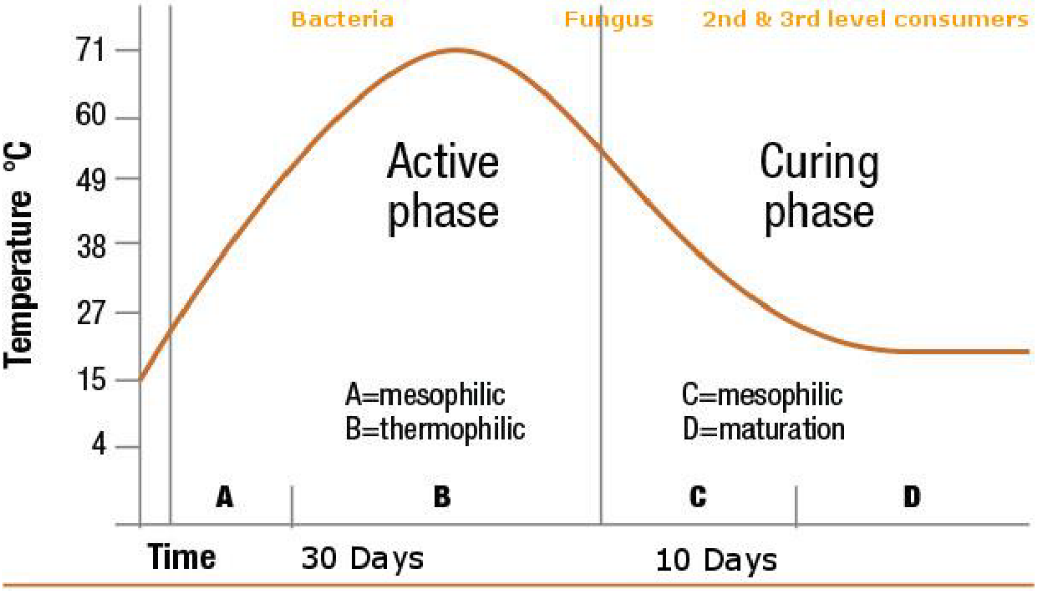
- Accelerated composting process.
- Kills weeds and weed seeds during composting.
- Kills plant diseases in the horticulture waste.
- Degradation or denaturisation of antibiotics and vermicides.
- Degradation of pesticide and herbicide residues in kitchen scraps.
- Discouraging to rodents and other pests.



Aerobic Hot composting has two phases-

Thermophilic and Mesophilic.

Thermophilic Phase: During this phase the temperature of the composting pile increases and provides the ideal environment for useful bacteria to thrive and multiply. The temperature remains in between 45°C to 65 °C. This phase generally lasts for around 30 days.



Mesophilic phase: During this phase, the temperature of the composting pile starts to decrease. Under these conditions, fungus and other second and third level consumers dominate the composting pile. The temperature remains less than 45 °C. The curing phase of the composting process is the Mesophilic phase. This phase lasts for at least 10 days.

Depending upon the space available with the Bulk Waste Generator there are three models of composting that are carried out in Balancing Bits

1. Non Mechanized – On Site Aerobic Composting
2. Semi Mechanized – On Site Aerobic composting
3. Semi Mechanized – Off Site Aerobic composting

- **Non-Mechanized –On Site Aerobic Composting**

This model is implemented for bulk waste generators who have enough space to carry out non mechanized composting.

Segregated waste received at the unit is further segregated to ensure not a single piece of plastic or other non-compostable wastes are present in the final substrate. This is followed by shredding, cutting to ensure consistency of the size of the substrate pieces and allow an easier and uniform processing.

Mixing of microbial enzymes, dry leaves and kitchen waste ensures that smaller air pockets are created, and the microbes are spread out evenly throughout the pile.

Turning the pile twice during the composting phase of 30 days ensures that the ideal temperature, aeration, and moisture conditions are maintained in the bins to ensure efficient functioning of microbes. The third turn takes place when the composting matter is moved to the curing bins.

The following equipment is used for the composting process.

Shredder: The shredder is used to shred kitchen waste as well as the dry leaves or other garden waste. The shredder helps to accelerate the composting process by breaking down the kitchen waste and dry leaves into smaller pieces. It is also used to shred the ready composted mulch, which makes it easier to sieve to get the fine grain compost.



- **Composting and Curing bins:**

Iron mesh bins are used for composting. The design of the bins and the air lung which comes along ensures enough air passes through the composting pile to ensure efficient aerobic process, at the same time the external covers and fibre sheet at the bottom ensures that moisture and temperature is retained to support right conditions for aerobic composting.

- **Semi Mechanized – On Site Aerobic Composting**

This model is implemented for bulk waste generators who do not have enough space to carry out non mechanized (natural) composting.

Segregated waste received at the unit is further segregated in second segregation process to ensure no bit of plastic or other non-compostable wastes are present in the final substrate. This is followed by crushing and dewatering the waste through a compact energy efficient crusher and dewaterer machine that removes the extra moisture from food waste using centrifugal force, it ensures consistency of the size of the substrate pieces, reduced moisture and allows easier and uniform processing. Mixing of microbial enzymes, dry leaves and kitchen waste ensures that smaller air pockets are created and ensures that the microbes are spread out evenly throughout the pile.

Turning the pile 2-3 times during the composting phase of 30 days ensures that the ideal temperature, aeration, and moisture conditions are maintained in the bins to ensure efficient functioning of microbes. The third turn takes place when the composting matter is moved to the curing bins.

- **Semi Mechanized –Off Site Aerobic composting**

This model is implemented for bulk waste generators who have severe space constraints in their premises to carry out waste management.

Segregated waste received at the unit is further segregated to ensure no bit of plastic or other non-compostable wastes are present in the final substrate. This is followed by crushing and dewatering the waste through a compact energy efficient crusher and dewatering machine that removes the extra moisture from food waste using centrifugal force, It ensure consistency of the size of the substrate pieces, reduced moisture and allow for easier and uniform processing.

This waste is then taken to Balancing Bits off-site composting facility where it is composted using Aerated composting bins and vermicomposting beds.

And then all the substrate pieces of food waste that is in uniform size is sent to their offsite facility known as central facility where all the offsite model's food waste is processed in fixed area through natural composting following all those two phases- thermophilic and mesophilic. Mixing of microbial enzymes, dry leaves and kitchen waste ensures that smaller air pockets are created and ensures that the microbes are spread out evenly throughout the pile.

Turning the pile 2-3 times during the composting phase of 30 days ensures that the ideal temperature, aeration and moisture conditions are maintained in the bins to ensure efficient functioning of microbes. The third turn takes place when the composting matter is moved to the curing bins.

Methodology

RESEARCH QUESTION

- How organic waste will contribute to our national economy?

RESEARCH OBJECTIVE

- To identify our organic waste as a modern economic opportunity for India

The methodology used in this study are observations of the technology being used by the employees at Balancing Bits' compost plant in the meanwhile of operations in the city Gurgaon/NCR and estimations based on revenue models of the organisation with having in-person discussions with core team members (Founder and Operations Manager) on practical ideas and studying related statistical data available.

The estimation of MSW generation in the Gurugram - a 'Millennium City' is carried out based on the number of domestic residents and the number of migrants (domestic and international) who migrate here for better earning opportunities from Uttar Pradesh, Bihar, West Bengal, Assam, Sikkim, Nepal etc. throughout the year in search of job or to start a business. The number reported a local population of Gurugram was 1.5

M people in 2021. In 2041, this figure of population has been projected to increase by 4.1 M people including local population and migrant workers. The MSW generation rate for the domestic population and migrants is assumed to be 1.084 Kg/person in 1 day. The future projections of MSW generation for the local population and migrants are calculated using a 36.5 % population growth rate in the two decades. Therefore, the Municipal Solid Waste generation will also increase accordingly.

As mentioned in the introduction, with managing our food waste we could balance our ecological needs with increase in our revenue streams. If Food Waste is properly managed, then we can reclaim our land area to be used in commercially viable model and on the other hand various types of gases could be avoided to be released in the air which causes health hazards. Moreover, we have tried to find out the revenue streams by reclaiming our land area and claiming carbon credits for the emissions in the organisation based on the previous studies on Gurgaon and current financial models of the organisation- Balancing Bits.

Also, keeping in mind for compost generation, we also considered the cost of substitution of chemical fertilizers, carbon credits and subtracted operational expenses which will cost us by deploying labours for the process to work. This study includes the revenue generated from, i) waste diversion from landfill, ii) environmental savings through CC, iii) fertilizer selling, iv) replacement of the equivalent quantity of N, P, K, and C nutrients, v) Operational Monthly Revenues.

Results and Discussions

The population of Gurugram city was 1.5 M people in 2011 census, so at the current growth stage, this population is expected to be around 4.1 M people in 2041. Consequently, the MSW generation was estimated to be 1 kg/day.

Gurugram is the industrial city of India, where many domestic migrants around the country visit and reside every year in search of better opportunities. Therefore, its waste generation compared to other cities is high. The MSW of Gurugram city consisted of ~71% organic food waste. The amount of OFW generation is 1100 Mt, which is projected to be 2900 Mt in the year 2041. The cumulative amount of OFW generated by the local population and Migrants will reach 2900 Mt in 2041. If utilized for making compost, this increase in the OFW production would result in an increasing calculated amount of compost production with the time that will be ranged from 85560 to 256680 Mt in the years 2022–2041. Implementing the methods to manage these resources could play an essential role in mitigating waste-associated pollution and becoming a source of industrial development and job creation for the local people.

The compost application to the soil will fulfil the nutrients demand and help to increase soil C content or organic matter, infiltration rate, water-holding capacity, sorptivity, and reduce cumulative evaporation. These are much required characteristics of the soils under cultivation in this semi-arid region, which are defined as poor organic matter, nutrient-deficient, and dry calcareous sandy soils. The compost application in such soil is considered to counteract nutrient deficiencies and improve physicochemical and biological properties. Its application will help mitigate the soil degradation problem in India. In addition to the shortterm benefits of nutrient supply and increment in organic matter content, the compost also has residual effects on soil fertility and crop yield. The build-up of organic matter in the soil by compost confers long-term nutrients release for approximately 6 years. These long-term residual effects of compost are challenging to estimate in our calculation. If we take the long-term influence of compost into account, compost's substitution value would be much higher during the subsequent years.

CH_4 is a well-known greenhouse gas, and its GWP is 25 CO_2 eq. for a 100-year time scale. It shows that this gas is 25 times more harmful in terms of global warming than CO_2 emission. Landfills are a significant source of CH_4 emissions around the globe. When solid waste is decomposed under anaerobic environmental conditions, especially in sanitary landfills, 40–60 % of this waste is converted into CH_4 production under deserted ecological conditions. Dumpsites contribute to CH_4 emissions by 64% in India. The estimation reveals that the compost production from OFW of India during 2010 to 2020 could have reduced 8.59 Gigaton of CH_4 production associated with this waste dumping into the landfill. The current system of landfills is not scientifically designed to collect produced gases from the dumped waste. Such massive greenhouse gas (GHG) production has a global warming potential from the food waste and therefore may serve as a significant source of environmental pollution and global warming in the future. With the continuation of current waste management techniques, the threat of global warming potential will, even more, be enhanced in 2041, if wise and sustainable waste management techniques, such as the implementation of CE model, will not be adopted. The release of other GHG emissions from the landfills to the atmosphere and discharge of concentrated leachate (with N, P, K, etc.), pollutants, pathogens into the soil and water bodies are causing severe environmental and public health concerns in the country. By adopting waste recycling technologies in the compost production technique as a potential contender, India can reduce MSW-related GHG emissions, including CH4. The problems associated with leachates, such as eutrophication of groundwater bodies and soil contamination in the areas of landfills, can also be reduced using compost production technology.

Composting of organic waste is a well-established process. One can use mechanized, in-vessel, conventional static, a turned heap, and windrow composting methods to produce compost. However Balancing Bits, uses aerobic hot composting and semi mechanised natural composting methods using upcycled MLPs Composting boxes. The compost production is a lengthy process and may take 30 to 45 days to get matured compost. It has been reported that the process can be optimized by adding few additives and moisture content can be optimized with controlling the temperature with adding some bacterial solutions.

Box composting is used as method at Balancing Bits which is a large-scale on-site production with minimum operational and maintenance costs. These composting systems consists of linear box rows with having curing boxes where compost materials are piled and cured to dry. The compost being prepared in the boxes is manually turned to facilitate aeration and improve the mixing of composted material constituents which consists of food waste with a layer of horticulture waste. This mixing results in a faster decomposition rate and homogeneous finished compost. This method is well established and adopted by many municipalities with some tweaks in the system. The development of a composting facility to recycle the OFW in Gurugram will have multiple benefits,

i) help solve the MSW problem, ii) create jobs for locals, and iii), a source of a significant amount of revenue generation.

This simple implementation could save food waste dumping costs as tipping (waste transportation and dumping) fees due to the waste diversion from the landfill to the recycling facility. At present, Gurugram is spending a cost of ₹1000/t for waste dumping into the landfill. It was estimated that Gurugram could have saved an amount of ₹350 Crore alone from waste dumping at Bandhwari in the year 2020. In addition to gate or tipping fees, this waste diversion could have generated a revenue of ₹350 Crore from not dumping the waste at Bandhwari which is at the outskirts of Gurugram. This technology can generate a revenue of ₹343 Crore from compost. In contradictory to the anaerobic digestion or biodiesel production can also be used as the compost production technology, since anaerobic composting is not preferred for plants as this results in not so high valued compost and on the other hand Biogas plant can also be used for OFW management but at present this plant is still to be inaugrated in July which can easily manage food waste from the nearby districts, which will be approximately two times higher in terms of saving from the environment by any proposed technology to date. These technologies is much more beneficial for solving the food waste problem in Gurugram. Hence, by implementing this, India can save vast amount from the environment.

The net revenue generation from the proposed composting technology is calculated by adding up the revenue generated by selling compost and environmental (tipping fee + carbon credits) savings. It is estimated that sustainable compost production technology can generate a net revenue worth of ₹10 Lakh Crores nationwide including all kind of revenue streams. With the installation of this compost production technology in Gurugram, the net revenue of ₹343 Crore can be added to the city's economy in a year. There is no additional and highly skilled labor required to recycle the food waste into compost. This technology can be implemented in any urban city, including Gurugram. The compost production technology in Gurugram is technically, economically, and environmentally the most suitable technology for solving the food waste problem on all over the city.

The ministry should enhance local organic fertilizer production and increase the area for organic agricultural practice. Currently, 2.78 million hectares area of India is under organic agriculture production or converted from conventional farming practices to an organic one, requiring N, P, and K nutrients in organic fertilizer (i.e., compost). %age of P is the lowest in the compost than all other significant nutrients requirements for organic agriculture production in compost. Other nutrients such as C, N, and K are also an integral part of the compost, and their %ages are even higher than P in the compost. If India meets P nutrient requirements, then C, N, and K requirements will automatically be met by applying the same quantity of compost. Thus, the compost produced from the food waste of Gurugram and other cities can partially fulfil Indian organic fertilizer demand. There is a need to explore the feasibility of implementing this technology for food waste produced in other major cities like Thiruvananthapuram, Paradip and other cities of Odisha & Kerala to meet organic fertilizer requirements in the country.

Compost can also be used to substitute inorganic fertilizers for crop production, especially in low-input agriculture. This organic fertilizer has a great potential to reduce farmer's dependence on commercial fertilizers. The complete substitution of commercial fertilizer with organic ones resulted in lower net benefits than their partial substitution with compost. Consequently, partial substitution of chemical fertilizer with compost will be more beneficial, especially in areas where conventional/organic agriculture is practiced, so there will also be a demand for compost in these regions. The production of compost from the food waste of various Indian cities can replace the imported organic fertilizers and locally produced chemical fertilizers to meet the local fertilizer requirement.

Way Forward & Recommendations

The proposed composting technology identified the great potential for sustainable recycling of the food waste of Gurugram. Implementation of this technology at large will produce organic fertilizer, which is imported to meet the demand for organic agriculture. The proposed technology would significantly reduce the landfill sites occupied by waste dumping and help solve the socio-economic and environmental problems associated with food waste disposal. The main culprits for fire spots in the dumpsites are methane and methane is released from the organic waste which is mixed with dry (recyclable) waste into the landfills. Those organic waste are known as Legacy waste (aged municipal solid waste or decomposed waste which contains scrap polymeric and combustible materials) which can be further treated with two of the existing methods namely, Bio-mining and Bio-capping.

Bio-mining includes segregation of waste to separate sand that can be used for agriculture and dry waste that will be sent to cement factories to be used as fuel. After completion of the entire process, the land becomes vacant and will be used for implementing other projects.

Bio- Capping involves placing a cover over contaminated material such as landfill waste or contaminated soil. Such covers are called “caps.” Caps do not destroy or remove contaminants. Instead, they isolate them and keep them in place to avoid the spread of contamination.

These two methods are being followed in Indore and Bhopal respectively, no doubt these scientific technologies are very new to us therefore we need to observe and study the data being retrieved from the ground after implementing these two technologies to manage our existing landfill areas. Although this can easily be managed if we do not dump our food waste in the dumpsites, its as simple as that. A point to be noticed is that there cannot be any kind of fire hazards if there are no methane generating food waste. Those can easily be avoided if and only if we dump scientifically our dry waste in the landfills. We are not trying to promote the idea of dumping but if it is the norm then why not scientifically instead?

Not a single study could be claimed as the full proof holistic approach to an objective and so this study is. It has been an immense full experience while studying and researching thought provoking stuff all over around the world. No doubt the only limitations we are facing is “Us”. Where there is a will, there is a way. And this willingness in our responsible youth will determine the future of the Indian "Waste" products.

In addition to that, there were many times when to ease up the calculation and explain the fact rather than being involved in calculations we were rounding of the figures to be easy understandable. Despite the several positive observations, the challenges of covering all aspects of compost production in a single analysis. Likewise, the current research only considered CH4 emissions from the landfill. It did not include other greenhouse gases (CO2, N2O, NO, and NO2) emissions and polluting ground water caused by the nutrient leaching from landfills. Future studies should also focus on releasing the toxic ammonia (NH3) and other GHG emissions from the waste dumping sites. Further studies should also emphasize in detail, the positive impact of improved food waste management on the ground water environmental quality and leachate releasing problems associated with the current landfill sites. The development of the composting facility can reduce environmental pollution and improve overall air & water quality. In addition, there are GHG emissions related to the composting process, compost packaging, transportation, and application to the field. All these emission calculations and their relevant impacts should be part of future studies, including eco-economic evaluation of the compost production using life cycle assessment and life cycle cost methodologies. The future prognosis can also assess the climate change mitigation potential of composting technology and its utilization in the Circular Economy concept worldwide. A more detailed analysis can evaluate job creation's economic impact in the composting business on the overall national economy since India is looking for an alternative/renewable business model to decrease its oil-import economy dependence. In the future, the current method used for assessing fertilizer replacement can further be improved by integrating nutrient release patterns from the compost with crop nutrient recoveries and yields. This detailed analysis will help understand the relationship between crop nutrient utilization efficiency and food production efficiency, which is the key to enhancing crop yields. The organic food demand is substantially increased worldwide, and India should be looking for the opportunity to expand its organic food production in the coming years with using organic fertilizers. Future-modelling studies can also focus on the revenue generated from the export of agricultural commodities utilizing compost production from food waste in India and around the globe. It will further close the nutrients open loop in the current food waste management and give the economic picture of the recycled products circularity in the global agriculture sector.

Conclusions

This pioneering study provides the recycling potential of food waste to produce organic fertilizer (i.e., compost) and its economic and environmental assessment as indicators of circular economy in managing food waste. It discusses an integrated economic and ecological analysis of compost production from food waste and its substitution potential to replace its competitive chemical fertilizers (urea, DAP, and SOP) to save and generate revenue as well. Recycling and reusability of garbage will help reduce the operational and environmental issues associated with current waste management practices and add considerable revenue to the national economy. Implementing this technology in the upcoming years will convert 2900 Mt food waste into 870 Mt of compost which will be beneficial for environment, economy, and human health. This technology can save India from the environment (tipping fee and CC) and all fertilizer substitution and generate handful amount from the fertilizer production. In total, this technology can add a net income of minimum 1 lakh crore into the national economy in 2041. As a result, it would help close the nutrients loop from the waste management issue and be the first step to convert the linear economic model of our country to a CE model following the India's goal of shifting from an exploitative model economy into a sustainable economy. This concept of compost production from food waste should be extended to the other cities of the India to meet the local organic fertilizer demand. It will not only solve the Kingdom's food waste associated problems, but it will also help to achieve the national goal of being Aatmanirbhar (Self Reliant).

References

Agency for Toxic Substances & Disease Registry. (2001, November). Retrieved from www.atsdr.cdc.gov: https://www.atsdr.cdc.gov/HAC/landfill/html/ch2.html

Agency, U. S. (2022, February 28). Composting At Home. p. 2. Retrieved from https://www.epa.gov/recycle/composting-home

Big Basket. (2022, July 2). Retrieved from Big Basket: https://www.bigbasket.com/pd/40024642/daily-dump-organic-compost-1-kg/

Carry On Composting. (2022). Retrieved from http://www.carryoncomposting.com/416920216

Central Pollution Control Board. (2000). Retrieved from cpcb.nic.in: https://cpcb.nic.in/municipal-solid-waste-rules/

COSTAGLIOLA, D. (2021). *Carbon Credit*. Retrieved from www.investopedia.com: https://www.investopedia.com/terms/c/carbon_credit.asp

Down To Earth. (2022, July 2). Retrieved from downtoearth.org.in: https://www.downtoearth.org.in/news/waste/solid-waste-management-rules-2016-53443

Dr. BP Naveen, R. M. (2018). *Waste Management: Issues and Solutions for a Rapidly Growing Satellite City in National Capital Region, India.* Gurugram: Research Gate. Retrieved June 2022, from https://www.researchgate.net/publication/324686691_Waste_Management_Issues_and_Solutions_for_a_Rapidly_Growing_Satellite_City_in_National_Capital_Region_India

EPA. (2022, May). Retrieved from epa.gov: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

Google. (2022).

Government of Haryana. (2022, July). Retrieved from gurugram.gov.in: https://gurugram.gov.in/about-district/

Gupta, M. Y. (2011). *Carbon Credit: A Step Towards Green Environment.*

Haryana Assembly. (2021, August). Retrieved from haryanaassembly.gov.in: https://haryanaassembly.gov.in/wp-content/uploads/2021/08/Starred-Question-No.-1132.pdf

Hindustan Times. (2021). Retrieved from https://www.hindustantimes.com/cities/delhi-news/delhi-metro-earns-19-5-crore-by-selling-3-55-million-carbon-credits-101632679060521.html

Indian Carbon. (2022). Retrieved from indiancarbon.org: https://www.indiancarbon.org/the-carbon-credit-market/#:~:text=The%20value%20of%20carbon%20credits,projected%20revenues%20are%20quite%20significant.

Naveen, D. B. (2018). *Waste Management: Issues and Solutions for a Rapidly Growing Satellite City in National Capital Region, India.* Research Gate. Retrieved from https://www.researchgate.net/publication/324686691_Waste_Management_Issues_and_Solutions_for_a_Rapidly_Growing_Satellite_City_in_National_Capital_Region_India

Non Residents Indian Online. (2022, July). Retrieved from https://nriol.com: https://nriol.com/india-statistics/biggest-cities-india.asp

PEDA. (2022). Retrieved from Clean Development Mechanism: https://www.peda.gov.in/clean-development-mechanism#:~:text=India%20is%20considered%20as%20the,over%20a%20period%20of%20time.

Ramanathan, M. R. (2011). Methane Flux from MSW Landfill Areas. *Assessment of Methane Flux from Municipal Solid Waste (MSW) Landfill Areas of Delhi, India*.

Sayara, T. (2020). MDPI. *Recycling of Organic Wastes through Composting*.

Singh, C. K. (2018). Quantitative analysis of the methane gas emissions from municipal solid waste in India. Retrieved from https://www.nature.com/articles/s41598-018-21326-9

Singh, S. C. (2022). *The Economic Times* . Retrieved from India plans own uniform carbon trading market: https://economictimes.indiatimes.com/industry/renewables/india-plans-own-uniform-carbon-trading-market/articleshow/91082527.cms?from=mdr

The Hindu. (2019, May 9). Retrieved from Making a molehill out of a landfill mountain in Delhi : https://www.thehindu.com/news/cities/Delhi/making-a-molehill-out-of-a-mountain/article27074265.ece

(2019). *The Role of Bioenergy in the Bioeconomy.* Retrieved from sciencedirect.com: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/landfill-gas

Wikipedia. (2003). Retrieved from Chicago Climate Exchange: https://en.wikipedia.org/wiki/Chicago_Climate_Exchange