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A CASE STUDY OF SOLID WASTE MANAGEMENT OF RRCAT, INDORE (NISARG-RUNA BIOGAS PLANT)

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This case study presents the economic analysis of **Solid Waste Management** with taking the exemplification of **Nisarg-Runa Bio Gas Plant of RRCAT, Indore.** Solid waste Management is now becomes a very important to implement across the Indian Cities because due to ***Swachhchh Bharat Abhiyaan,*** garbage has regularly been collected by municipal corporation, but only collection of the garbage is not the final solution. Concerning the same, this study suggest that Bio Gas Plant is the best alternative for wet (bio-degradable) waste which decomposed the wet waste into manure form and produced the bio gas too that can be further used for the purpose of cooking. Moreover, citizen will enjoy the positive externalities in terms of fresh and pure air, positive energy; pleasure and healthy environment for living a better quality of life.

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Executive Summary

RRCAT had felt the need of Bio Gas Plant for managing the wet waste of campus in order to get rid from all these sludge; uncleanliness and health issues. Though, the motto was not the production of gas or of manure, but to manage the bio degradable waste in environment friendly manner. Therefore, RRCAT installed Nisarg - Runa Bio Gas plant at campus on 26 July, 2014 to get rid from wet waste management problem and in addition to it they are also getting bio gas and manure as a byproduct. This was also the part of "Clean and Green Campus" campaign recently. In the premises of RRCAT, total number of houses is 1000, produces all an average 400 kg waste per day implies that around 0.4 kg per household and around 100 kg wet waste comes from guest house during winter season because in this season markets are plentiful with different- different vegetables and fruits – supply side view. Intake of vegetables and fruits are also high during wintertime. However, during summer the wet waste figure comes down to 250 to 300 kg that is to say around 0.3 per kg per households. The full capacity of Nisarg - Runa Bio Gas Plant is 1 ton, but currently it is working on 500 kg means half of the capacity is unutilized. More technically, it is underutilized. The complete process of Bio Gas Plant is described below in brief:

Firstly, the garbage has collected from around 1000 households, guest house, and shopping centers etc. every day except Sundays. Since households are maintaining separate bins for bio-degradable (wet) waste thereafter the collected garbage arrive at Bio-gas plant for further processing.

Secondly, the garbage goes from the micro scrutiny wherein the plastic, pins and stones etc. are segregated. After that, garbage is uploaded on incline slide at the same time water is taped over slide keeping in mind that 1 kg garbage require 1 liter water. In this slide, one magnetic plate is installed on last point for detecting the pins and metallic things away from the flow which could be by chance remained in waste despite after micro scrutiny.

Now the garbage comes in grinder through slide with the flow of water wherein grinder crushes the bio degradable waste then it goes into pre digester tank. Though, position of grinder is above than pre digester tank so that waste slurry is automatically draining off into pre digester tank through the effect of gravitational force.

Complete decomposition of slurry requires minimum 4 to 5 days due to aerobic chemical reactions. Aerobic reaction takes place in presence of oxygen because of aerobic bacteria. So for maintaining the process properly the first chamber of pre-digester tank is kept open during the process for about 2 to 3 hours, so that proper supply of oxygen will be channelizes into tank that will

help in germination of aerobic bacteria. After decomposition the slurry is automatically shifted into second chamber wherein further putrefaction goes on in next 4-5 days.

Thereafter, decomposed slurry goes into main chamber in between there is one inspection chamber where the ph-value is measured so that process in main digester will happen be rightly otherwise output in form of gas is not optimal. According to scientists, the ph-value in Inspection Chamber-I should be five minimum and can be more than five indicating appropriate decomposition and putrefaction of slurry in pre-digester tank.

The main digester tank is floating dome and made up of two chambers having one baffle wall open from above. The gas holder is made of ms-sheet weighs 1.6 tons. This gas holder is surrounded by double wall and in between the walls water is filled for sealing. In main digester tank the process of conversion of gas from decomposed slurry requires minimum 10 to 15 days. Thereafter, the remaining slurry flows to manure pit. Here again, one inspection chamber exists in between the main digester tank and manure pit. The ph-value is measured which should be minimum 6 to 7. The value confirms the appropriateness of process. There are two manure pit constructed because continuous flow of wet manure in one pit causes moisture and hamper the

process of dryness of compost. For same inspection chamber consists one indigenous valve for diverting the flow of manure from one pit to another.

Finally, the output in form of fertilizer is ready to use after dried. As noted above that manure pit is divided into two parts, as one gets full the manure is diverted to another one, usually in fifteen days the manure gets dried out. Here manure comes with moisture and containing water, so in order to collect this water for further use in maintaining greenery in garden or for nearby vermi-culture plant, in the bottom of manure pit i.e. on surface layer, gravel and sand is spread on through which water is falling down and collected into a water tank. After drying the compost now is available for use in form of fertilizer in gardens and nursery.

Despite not operationally fuller utilization, this plant is produced manure of worth around Rs. 1 lac per annum and Biogas too, which serves around 200 people's cooking per day in the guesthouse (150 students & 50 guests). However, the full capacity of guest house is 350 people and guest house is not fully fueled by Bio Gas, but 30- 40 % of total gas consumption contributed by Bio Gas. The RRCAT guest house's catering part is given on contractual basis and bio gas takes double time than LPG and requires special kind of burner with bigger pores. Thus, for promoting the usage of produced biogas, RRCAT subsidized its price to its actual price.

Prologue

The organization RRCAT was facing the problems of muck; ret wet waste and its malodor, causing by in-campus households. Slowly but certainly, converting the greenery of campus into sty, hence it becomes worrisome issue for RRCAT. It was not merely the problem of waste but rather more than that, if we see this as health concerning issue. These issues of waste management and its consequences coerce the scientist group of RRCAT to mull over on it, for resolving not only the problem of waste but also from its negative consequences. After contemplating and reviewing all possible alternatives, RRCAT had felt the need of Bio Gas Plant for managing the wet waste of campus in order to get rid from all these sludge; uncleanliness and health issues. Though, the motto was not the production of gas or of manure, but to manage bio degradable garbage in most environment friendly manner. The RRCAT installed Nisarg Runa Bio Gas plant at campus on 26 July, 2014 to get rid from wet waste management problem and in addition to it they are also getting bio gas and manure as a byproduct. This was also the part of “Clean and Green Campus” campaign recently. This is considered as one of the best solid waste management Practice in the residential area with around 1000 households.

For sustaining this project effectively, first and foremost challenge was segregation of wet waste. For same, they asked their households to keep their waste in segregate way i.e. two different dustbins for wet waste and dry waste. Though, it was not so simple pragmatically as it is theoretically. Since, Change is hard at first, because generally people have a tendency to not to adopt change easily. During the discussion with chief engineer Parchani sir, it is found that despite going 3 years and more still notorious family does not support waste segregation mechanism. He also suggested that instead of managing waste, we should rather give importance on reducing the waste by our own practices, in his view it is a big task.

In the premises of RRCAT, total number of houses is 1000, produces all an average 400 kg waste per day around 0.4 kg per household and around 100 kg wet waste comes from guest house during winter season because in this season markets are plentiful with different types of vegetables and fruits – supply side view. Intake of vegetables and fruits are also high during wintertime. However, during summer the wet waste figures come down to 250 to 300 kg that is to say around 0.3 per kg per households. The full capacity of Nisarg RUNA Bio Gas Plant is 1 ton, but currently it is working on 500 kg means half of the capacity is unutilized. More technically, it is underutilized. Despite not operationally fuller utilization, this plant is produced

manure of worth around Rs. 1 lac and Biogas too which serves around 200 people's cooking per day in the guesthouse (150 students & 50 guests). However, the full capacity of guest house is 350 people and guest house is not fully fueled by Bio Gas, but 30- 40 % of total gas consumption contributed by Bio Gas. The RRCAT guest house's catering part is given on contractual basis and one big drawback of bio gas is that it works slowly as compared to LPG usually it takes double time than LPG and requires special kind of burner with bigger pores. Thus, it might happen that Contractual caterer deny to use bio gas for his cooking. That's why for promoting the usage of produced biogas, RRCAT subsidized its price to its actual price for promoting its use and for utilizing the resources optimally.

In that way, once the ret-wet considered as garbage and headache now after scientifically processing, becomes useful, and saving 1 lac per year of manure using in the campus on the name of maintenance and serving 200 persons breakfast daily.

Therefore, RRCAT's engineer termed this as Garbage to Gold.

Bio- Gas Plant: Complete Process

1. Collection of Garbage

Picture 1: Separate bins for collecting garbage

Currently, urban households maintain two different bins for keeping waste; one for wet waste and second for dry waste in effect of Swachhch Bharat Mission. However, this practice has been a part of Clean and Green Campus of RRCAT since 2014 in which households are maintaining separate bin for bio-degradable (wet) waste (Pic._1) which is collected by contractor who manage all activities of Gas Plant. In actual fact, contractor has assigned 4-5 people for collecting the garbage from around 1000 households, guest house, and shopping centers etc. every day except Sunday. Collection of garbage includes bringing separate bins of garbage from households and offloading into trolley that is made of two chambers then uploading wet waste trolley into

cart for driving up to Receiving Unit (Pic._2 & Pic._3). This whole process takes time of two to three hours and around 2'O clock the collected garbage arrive at Bio-gas plant for further processing.

Picture 2 and 3: Offloading the garbage at Receiving Unit

2. Waste Segregation

Picture 4: Segregated Waste

Following the collection of garbage, manually segregation of wet waste is being done by laborers in segregation comportment nearby the processing

room. The segregation process comprising micro-level inspection of collected waste and assuring that there is no any sort of obstruct or hampering object like plastic spoons; polythene, rope; hard stone; steel pin; safety pin or any other material remained in waste because, existence of these sorts of items can be hampered the grinder. After inspection, this garbage is brought into processing room (Pic._4).

3. Processing Room

Picture 5: Measurement of waste

Picture 6: Micro-Inspection over slide

Here, measurement of total quantity waste is taken by labor (Pic._5) for ascertaining the total weight of collected garbage so as it could not cross the limit as the capacity of plant is metric ton. Usually, 400-500 kg waste is collected during winters while in summer and rainy season around 300 kg garbage is collected. Though, the minimum required amount is 300 kg for function the plant properly. In such a way, a household generates

approximately 0.45 kg wet waste during winter and 0.3 kg in other seasons. After that, garbage is uploaded on incline slide whereon one magnetic plate (Pic._7) is installed on last point for dragging the pins and metallic things away from the flow at the same time water is taped over slide keeping in mind that 1 kg garbage require 1 liter water (Pic._6). Water is added to control the acidic nature of the waste and for proper aerobic reaction which would be taking place in pre digester tank.

Picture 7: Magnetic Point under slide

During the winter hot water is also added (Pic._8) for maintaining the chemical reactions because in cold water aerobic reactions do not happen perfectly and creates unwanted delay in process.

4. Grinding

Here, the actual process of bio gas from waste is started. In this process grinder crushes the bio degradable waste with water (Pic._8). Grinder is connected with pre digester tank through a pipe. The Plant is designed in a

way where the position of grinder is above than pre digester tank so that waste slurry is automatically draining off into pre digester tank through the effect of gravitational force (Pic._9). The connected pip is tilt however for stopping the speedy flow of slurry in pre digester tank (Pic._9).

Picture 8: Operational Grinder during winter (warm water)

Picture 9: Indigenous Technique (Tilt Pipe & Gravity)

5. Pre-digester Tank

Picture 10: Pre-digester Tank (Two Chambers)

This tank is made of two chambers (Pic._10) and connected from below specifically the surface of both chamber is common while swinging baffle wall is separated above portions. Though, completely decomposition of slurry requires minimum 4 to 5 days due to aerobic chemical reactions. Aerobic reaction takes place in presence of oxygen because of aerobic bacteria. So for maintaining the process properly the first chamber of pre-digester tank is kept open during the process (Pic._11) for about 2 to 3 hours so that proper supply of oxygen will be channelizes into tank that will help in germination of aerobic bacteria. After decomposition the slurry is automatically shifted into second chamber wherein further putrefaction goes on in next 4-5 days.

Picture 11: Pre-digester Tank (open during the process for Aerobic reactions)

6. Inspection Chamber-I

Picture 12: Inspection Chamber-I

Here the ph-value is measured (Pic._12) so that process is main digester will happen be rightly otherwise output in form of gas is not optimal. According to scientists, the ph-value in Inspection Chamber-I should be five minimum and

can be more than five (Pic._13) indicating appropriate decomposition and putrefaction of slurry in pre-digester tank. It has been observed that during winter season there is a problem in getting ph-value appropriately because in cold water germination of aerobic bacteria not happen properly hence ultimately decomposition process spoiled and affects remaining main process of bio gas conversion.

Picture 13: Ph Value

7. Chemical Process

Aerobic reaction takes place in presence of oxygen because of aerobic bacteria and to supply oxygen into pre digester tank one compressor (Pic._14) is there. These bacteria help in breaking down the waste. Moreover, due to aerobic reaction smell of waste gets dissolve. The slurry should not be too acidic otherwise there are chances that the slurry will change into gas in service chamber only. To control the acidic nature more amount of wet waste (cow dunk) and more amount of water is added.

Picture 14: Compressor

8. Main-Digester Tank

Picture 15: Floating Dome

The main digester tank is floating dome (Pic._15) and made up of two chambers having one baffle wall open from above. The gas holder is made of ms-sheet weighs 1.6 tons. This gas holder is surrounded by double wall and in between the walls water is filled (Pic._16) for sealing.

Picture 16: Floating Dome

9. Technicalities and Chemical Understandings

The process in main chamber takes 14 to 15 days for complete decomposition. The output in form of gas contains 75 Percent methane (CH4); 20 per cent Carbon-di-oxide (CO2) and water vapor. For releasing the collected water vapors one pipe is tacked on down side with gas exist pipe. Though, the guest house is not near to Bio gas plant, hence blower (Pic._17) is used for forwarding the bio gas to Guest House.

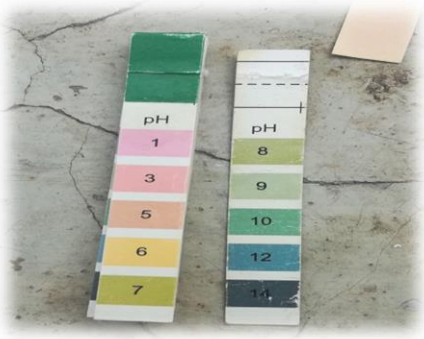
Picture 17: Blower

10. Inspection Chamber

11.Picture 18: Inspection Chamber-II (Indigenous valve)

Here again the ph-value is measured which should be minimum 6 to 7 (Pic._19). The value confirms the appropriateness of process. This chamber connected with manure pit. There are two manure pit constructed (Pic._18) because continuous flow of wet manure in one pit causes moisture and hamper the process of dryness of compost. For same inspection chamber consists one indigenous valve (Pic._18) for diverting the flow of manure from one pit to another.

Picture 19: Ph Value



11. Manure Pit

Picture 20: Manure Pit

Finally the output in form of fertilizer is ready to use after dried. As noted above that manure pit is divided into two parts, as one gets full the manure is diverted to another one, usually in fifteen days the manure gets dried out (Pic._20). Here manure comes with moisture and containing water, so in order to collect this water for further use in maintaining greenery in

garden or for nearby vermin culture plant in the bottom of manure pit i.e. on surface layer of gravel and sand is spread on through which water is falling down and collected into a water tank. After drying the compost now is available for use in form of fertilizer in gardens and nursery (Pic._21). It is found that the remained dried manure is 30 per cent of total garbage.

Picture 21: Compost (available for garden)

12. Disposed Water Tank

In this tank extra residuary water is collected (Pic._22) draining off from manure pit. Currently this collected water is used in nearby vermi-culture plant (Pic._23). As the plant will kick off the working on full capacity so it can be

further reused in bio-gas plant itself. The water can be used in gardens and parks.

Picture 22: Remaining Water for reuse

Picture 23: Vermi Culture Plant

13. Use of produced Bio Gas

Aforementioned that for using the bio gas special burners is required with bigger pours shown in above pic. 24. Though, the bio gas takes almost double time in cooking than LPG, therefore the guest house cooks use this gas

in cooking the rice, pulses, and breakfast for around 200 people. In this way, 30 to 40 per cent gas consumption of guest house is contributed by produced Bio Gas.

Picture 24: Bio Gas Utilization in Guest House

Financial Implications

The RRCAT organization is outsourced full operational part of bio gas plant through annual contract basis. This contract includes the entire process from collection the garbage to dispatch of dried manure. Present, contractual costs 30,000 rupees per month which includes:

- Collection of wet waste from around 1000 households, shopping centers, and guest house every day except Sundays.
- Offloading of this collected garbage to receiving unit.

- Segregation of wet-waste and then measurement of waste.
- Uploading the garbage on slide gradually and maintain the water supply accordingly. Moreover, during winter also maintains minimum amount of temperature through supplying hot water.
- Maintain the supply of oxygen through compressor and by opening up the pre digester tank for two to three hours.
- Diversion of manure pit valve timely.
- Collection of dried manure.
- Maintenance of record including weight of waste; time hours of blower running and compressor running.
- All in all, contract covers all operational part of Bio Gas Plant.
- In addition to it, the power consumption of blower; compressor; geyser and water pump cost around 5000 to 6000 rupees monthly.

Moreover, in the form of output around 600 to 650 kilo gram manure is formed monthly and around 190 to 200 cubic meter gas is produced monthly. The market price of Bio Gas is 24 rupees per cubic meter while the price of compost is 10 rupees per kg. In that way, the total revenue will be sum total of gas receipt 4,800 rupees and manure receipt 6,000 rupees i.e. 10,800 rupees.

Mathematically,

Cost of cleanliness per household = Cost- Revenue/ Number of households

Cost of cleanliness per household =35,000 – 10,800/ 1000

Cost of cleanliness per household =24.2 rupees

The cost of cleanliness per household is coming out to be only 22 rupees per month which is too meager in magnitude. As above documented that for promoting the use of bio gas the RRCAT organizations subsidized its price and sell it on only rupees 10 per cubic meter which is far less than the market price and LPG price too. The cost of cleanliness per household now becomes 25 rupees per month. Again, this is not too big value for any household to pay for maintaining the cleanliness. In this way, the Bio Gas Plant can be seen as a very effective project as it costs 24 to 27 rupees per family for maintaining the cleanliness and greenery by which are really inaccessible in these days.

Moreover, it also produced manure which can be used or sold for maintaining the greenery and Bio gas which also can be used in cooking by disposing the bio degradable waste.

Besides it, this cost comes when plant is working underutilization as it gets started working with full capacity the amount of produced manure and gas will automatically increase thereby the per family per month cost will definitely come down.

Beyond that, if we see the maintained greenery in the campus wherein the produced compost is used so we can only imagine the original

effectiveness and utility of the plant which cannot be monetize in rupee terms implying the positive externalities. Activities that have positive effects on unrelated third parties are considered positive externalities. For say, the maintained greenery and cleanliness in the campus by organization provides positive benefits in terms of fresh and pure air, positive energy; pleasure and healthy environment to the residents for living a better quality of life.

Picture 25: Glimpse of RRCAT Campus

Challenges

- Notorious families who do not maintain separate bins and illogically irritate waste collector as it is prevailing human tendency.
- By mistake, if there is any harmful items in wet bin like pins; plastic spoons; small stones and substance of rope.
- Maintenance of minimum standard amount of waste for proper functioning the plant regularly especially during summer.
- Be suspicious on proper working of contractual labor.
- During the winter, due to cold, proper aerobic reactions do not take place even in span of five days in pre digester tank. That is why; proper formulation of gas could not be materialized in main digester tank.
- Timely testing of Ph Value in both Inspection Chambers for smooth process.
- Timely conversion of compost in manure pit for fuller dried.

Best Practices

- Maintain separate bins for dry waste and wet waste since 2014.
- Collected wet waste from households; shopping malls and guest house.
- Utilizes Produced bio gas in guest house.
- Subsidized biogas price to its actual price for promoting the usage of produced biogas in RRCAT guest house.
- Optimally utilizes manure in their own campus for maintaining the greenery.
- Lastly, disposed water also use in gardening and in vermin culture plant.
- Along with Bio Gas Plant, The RRCAT organization also operates Vermi-Culture Plant by using its own garden waste.
- All in all, optimally utilizes all natural resources and by doing so verifies the name of Bio Gas Plant –Nisarg Runa (Nature's debt).