"Life Cycle Assessment of Common Effluent Treatment Plant In Food Industry"

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Abstract- *Minimization of pollution, caused by small and medium-scale industries has become an issue of prime importance. Hence, for the same, waste minimization by adopting of greener and cleaner production technologies and are being prioritized in India. Collective treatment at a centralized facility, known as the CETP, is being widely accepted to overcome the shortcomings associated with effluent treatment in small to medium enterprises. First CETP was constructed in1985 in Jeedimelta near Hyderabad. CETP was followed by other states in TN, MP,Gujarat, and Maharashtra.CETP was promoted by MoEF in 1984 to treat wastewater from small and medium scale industries sector (SMIs).*

A bulk environmental pollution is caused by SMIs. Small scale industries policy does not consider proper environmental planning. Thus, for the effluent from SSIs the concept of CETP was introduced. The MoEF has instructed the SPCB to establish CETPs in different industrial estates in respective states. It said that the central will provide upto 25% of the total cost of CETP and the remaining should be contributed by state government and industries.

In this paper, for large scale industries, the structural design and operational concepts of a Common Effluent Treatment Plant (CETP) is discussed in detail. A case study of Food and Beverage Industry in Nagpur Maharashtra, India has been undertaken.The design parameters were considered for the study of the quality and quantity aspects of a CETP. The study to justify operational cost of the CETP plant in terms of Biogas Generation and utilization in comparison to conventional sources of energy has been undertaken. It is revealed that along with minimal or negligible waste disposal, the biogas generation from the plant is sufficient and effectively for energy production required for running of the industry. Finally, in order to complement a step forward in the direction of protection of environment, introduction of the concept of CETP is a meaningful front.

Keywords- Minimisation of pollution, collective treatment, common effluent treatment plant, biogas generation and utilization, environmental protection.

I. INTRODUCTION

For the purpose of mitigation and reduction of environmental degradation caused by CETPs, alternative production methods are implemented which are relatively safe to environment. Further, it is being encouraged to minimize the generation of waste. Moreover, in CETPs, adoption of CETP can help conserve environment and in a nutshell, is considered to be a viable solution to present crisis.

In spite of the knowledge that every industrial unit will consider operation of its own plant, the overall discharge of emission by the group of industries may exceed the emissions from that of a larger industry. Since MSMEs generally adopt, as a cost saving tendency, production techniques which are neither efficient nor effective. Thus, the above occurs. Further, due to shortcomings in space, technical implementation, CETPs are fast gaining popularity and acceptability for mitigation of the generated waste which would otherwise be disposed in the environment, leading to much harm to the flora and fauna.

1. Present Count of CETP's in India

The following data regarding CETPs in India is obtained from GOVERNMENT OF INDIA MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

Table:1 Statewise of CETP's in India[7]

State/Union Territory	Number of CETPs
Andhra Pradesh	11
Gujarat	30
Haryana	14
Himachal Pradesh	1
Jammu Kashmir	1
Jharkhand	1
Karnataka	9
Kerala	5
Madhya Pradesh	1
Maharashtra	27
NCR of Delhi	13
Punjab	4
Rajasthan	14
Tamil Nadu	49
Uttar Pradesh	8
Uttarakhand	4
West Bengal	1
TOTAL	193

2. Design and Operational Aspects of CETP

The important aspects discussing the design and working of CETP are enumerated as follows. firstly, the industry type and the properties of the discharged wastewater. The input and output differences in the discharge. Further, if and how thw pre-treatment is performed. Finally, the collection, collation and conveyor system of the matter and the disposal site.

In order to analyse the treatment procedure, the wastewater must first be filtered and segregated according to its properties like COD or TDS. The different treatment procedures to be followed on the basis of the properties are discussed as follows.

- Firstly, neutralization is performed fir the highly acidic and/or highly basic effluents. For the removal of the suspended particles sedimentation and decantation is performed.
- Secondly, purification is the priority. For thie purpose, anaerobic, aerobic and microbial action is implemented.
- Thirdly, nutrients like N and P are washed off. For the purpose, different type of method maube used like micro filtration, activated carbon filters and sand filters, ultra-filtration, , reverse osmosis, ion exchange, UV filtration etc
- Next is the management of sludge**.** This includes the management of diffent type sof sludge generated. Further, this treatment method includes primary, raw and activated sludge.

II. LITERATURE REVIEW

Extensive literature review was undertaken for the purpose of studying the design and applicability of CETP for industrial cluster was undertaken. The excerpt of the review is elucidated as follows.

S. Al-Dosary, M.M. Galal and H. Abdel-Halim et.al. explained that LCA is an effective environmental tool which can allow the estimation and quantification of possible environmental damages related to a wastewater treatment process.

R. H. C. Emerson, G. K. Morse et. al discuss in their paper titled "life cycle analysis of small scale sewage treatment processes" regarding specific issues that arise in assessment of effluent treatment systems.

George Barjoveanu, Carmen Teodosiu in their work pulished in journal "Water science and Technology", titled as "Life Cycle Assessment of a Wastewater Treatment Plant Focused on Material and Energy Flows", explained that the analytical results are helpful for the design and operation of wastewater treatment plants in a more feasible and effective manner, relusting in proper implantation and post development service.

Andrez Almanza Ramirez, Dr. Luis Armando Bernal et.al. and D. Godin, C. Bouchard say that the LCA is a promising approach to more efficiently assess the environmental life cycle of a WWTP. Further, that LCA will give the right direction to define where the efforts need to be focused in their works titled, "Life cycle assessment for wastewater treatment in the chemical industry " and "LCA of wastewater treatment systems: Introducing a net environmental benefit approach", respectively.

There is negative impact on the environment and the aquatic life present in the locality, the above was concluded by Amit P. Choudhary and Govind pandey in their paper "Design and Operational Aspects of Common Effluent Treatment Plant in GIDA Project Area of Gorakhpur (U. P.)".

III. PLANNING OF CETP

Since CETP is related to the centralized collective treatment plant for a cluster of industries whose disposals is collected and treated collectively.

Table 2: Sources Of Effluent

Sr. no	Sources	Effluent generation in m^3
1	Simple Foods Products Pvt. Ltd.	80
2	Central Foods Products (Nagpur) Pvt. Ltd.	50
3	Krishi Udyog Pvt. Ltd.	100
4	Kasana Foods Products Pvt. Ltd.	150
5	Komal Foods Products Pvt. Ltd.	160
6	Frozen Foods Products Pvt. Ltd.	100
7	Maples Great Day Foods Pvt. Ltd.	10
8	Hariomkar Foods Products Pvt. Ltd.	750

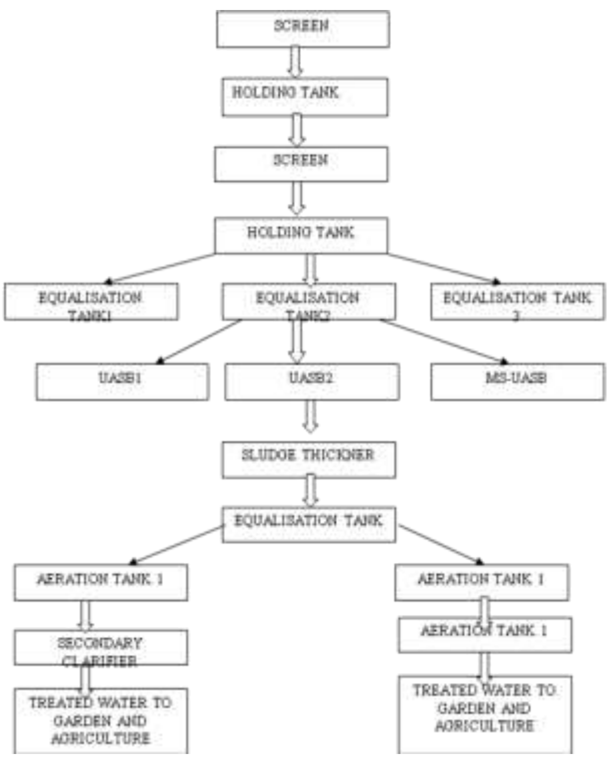
The various industries and their effluent generation is as given above are considered for the purpose of study for establishing of CETP.

IV. STRUCTURE AND LAYOUT OF THE PLANT

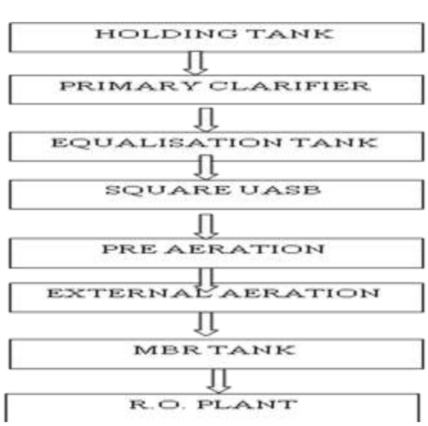
The design and the basic structure of the CET Plant is explained with the following flowcharts.

The above two flowcharts shows the basic design and working structure of the plant. It can be observed that the effluent generated collected from various industries can be treated effectively. The process subsequently provides with methodology to produce biogas, which can be used to generate energy and finally the treated water is utilized for flushing, gardening, agriculture, civil construction and R.O water making purposes.

CETP FLOW CHART 1



CETP FLOW CHART 2



Design and Operational Aspects

The major criteria include minimal cost and corresponding shape and size of the plant. The properties mentioned as in second treatment parameter as explained above, of wastewater, are considered during the design process.

Further, the additional aspect of operational aspects is the generation of the biogas. The quality and applicability of the biogas generated for the purpose of energy generation which can then be utilized for the purpose of operation of the industry under study.

The cost reduction incorporated by the usage of the biogas instead of the conventional methods of energy generation is also a matter of study. Finally, establishing of a CETP not only helps in management of the wastage effectively but also enables enormous cost saving by utilization of biogas generated as the byproduct of the treatment process.

For the above study, a case study will be undertaken and data would be collected in order to determine the feasibility of the project. Morover, a comparative study would be undertaken to determine the cost saving that can be achieved by doing away with the conventional method of energy generation.

Area of study

Fig.1: CETP of Food Industry

For the purpose of case study, CETP of Food and Beverage Industry was taken. Extensive experimental study was done and sufficient data was collected to proceed towards determination of feasibility, and cost savings that can be incurred in the project.

The methodology undertaken for the case study is mentioned as follows.

1. Influent and Effluent of CETP in terms of
2. COD and suspended solids.
3. Variations of effluent COD with respect to flowrate in UASB-1,2 and 3.
4. Total biogas production (2018-19).
5. Total biogas consumption (2018-19).
6. Cost analysis which include total electricity cost, manpower required and their respective wages, operation and maintenance cost, and chemicals consumption.
7. Total profit to the industry per month.
8. Environmental Impact Analysis which include air ambient quality monitoring

Table 3. Influent and effluent parameters of CETP

Parameters	Influent(inlet of CETP)	Effluent(final outlet of CETP)	Removal %
COD	25000-30000mg/l	20-40mg/l	99.89%
Suspended Solids	15000-20000mg/l	20-30mg/l	99.85%

Table 4. Variations of effluent COD wrt flowrate in USAB-1

Flowrate	Average Influent COD mg/l observed	Average Effluent COD mg/l observed	%Removal
7m3/hr	9000	2000	77.7
5-6m3/hr	9558	1935	79.7
3-4m3/hr	9235	800	91.3
1-2m3/hr	9347	520	94.4

Table 5. Variations of effluent COD wrt flowrate in USAB -2.

Flowrate	Average Influent COD mg/l observed	Average Effluent COD mg/l observed	%Removal
7m3/hr	9100	2001	78.01
5-6m3/hr	9878	1620	83.5
3-4m3/hr	9245	900	90.2
1-2m3/hr	9269	480	94.8

Table 6. Variation of effluent COD wrt flowrate in USAB-3.

Flowrate	Average Influent COD mg/l observed	Average Effluent COD	%Removal
12-14m^3/hr	9100	2001	78.01
8-12 m^3/hr	9878	1620	83.5
5-8 m^3/hr	9245	900	90.2
1-5 m^3/hr	9269	480	94.8

Observations

1. 3-4m^3/hr flow rate is considered to be the most efficient COD removal rate
2. 3-4m^3/hr flow rate is considered to be the most efficient COD removal flow rate
3. 8-12m^3/hr flow rate is considered to be the most efficient COD removal flow rate

Biogas production sources are USAB and anaerobic sludge digester. Further, depending on the atmospheric conditions, the production leve;s vary. However, in an average 4000-5000 m^3 of biogas is produced. Following table shows the biogas production in the period 2018-19.

Table 7. Total biogas production in m^3

Month\year	2018	2019
January		90125
February		100652
March		121005
April		125546
May		128256
August	100765	
September	122595	
October	113643	
November	95640	
December	95640	

It can be clearly observed that Biogas production bacteria need temperatures of more than 15°C to produce methane. This limits biogas use in colder climates. Therefore there is a gradual decrease in biogas production during winter season.

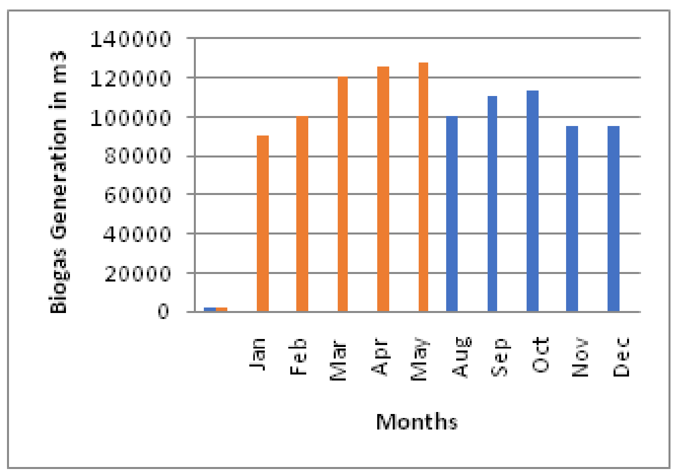


Fig. 2. Biogas Generation in 2018

Cost Analysis

Now, the most important part of the analysis is discussed. the cost analysis undertaken by calculation of total expenses incurred in running the plant which covers electricity, manpower, wages, operation and maintenance costs, and chemicals requires for the process.

Approximate Total expense to run CETP per month is around Rs.8,16,500

Table 8 portrays the most important factor i.e., cost benefits that would be attained by implantation of the project and utilization of the biogas. **Monthly Cost Saving of Fuel due to Biogas generation is around Rs.35,53,890**

Table 8. Total expenses to run CETP..

Sr. No	Cost sections	Total Cost/ month
1	Electricity/power	48000Rs
2	Manpower	406500Rs
3	O&M	43000Rs
4	Chemical consumption	319000Rs
	TOTAL	**8,16,500Rs**

Table 9. Biogas cost benefits to the industry.

SR. No	Different Unit	Biogas Running hrs	Saving Fuel	Saving Fuel usage/hr	Saving Fuel Rate (Rs.)	Quantity of Saving fuel/ day if Biogas is unavailable	Total Savings (Rs)
1	Peanut Roaster x 2	22	Diesel/ lit	18 lit/hr	Rs 66.65	792 lit	52786.8 Rs
2	Murmura Roaster	22	Diesel/lit	10lit/hr	Rs 66.65	220 lit	14663 Rs
3	Canteen (6 burner)	17	L.P.G./kg	0.95kg/hr	Rs 60.12	95 Kg	5711.4 Rs
4	Gulab jamun section (10 burners)	10	L.P.G./kg	0.95kg/hr	Rs 60.12	95 kg	5711.4 Rs
5	Papad plant x3	10	Diesel/lit	6lit/hr	Rs 66.65	180 lit	11997 Rs
6	Simple Boiler	15	Wood/kg	20kg/hr	Rs 4	300 kg	1200 Rs
7	Hariomakar Peanut Roaster	22	Diesel/lit	18lit/hr	Rs 66.65	396 lit	26393.4 Rs
						Total Savings/day	118463 Rs/day

Environmental Analysis

The next important factor to be considered to examine the effectiveness and feasibility is the impact the particular project has on the environment. Therefore, it is of prime importance to perform the Environmental analysis.

The methodology undertaken for the purpose of environmental analysis is as follows

- Environmental Impact assessment will be done with the help of Respiratory Dust sampler (RDS) machine.
- 6 Important considerable Parameters can be studied with this machine which are- SO_2 , NO_2, Ozone(O_3), Ammonia(NH_3), CO_2 and CH_4.
- Further, air ambient quality monitoring was also performed.

Table 10. Air ambient quality monitoring.

Sr. no	Parameters	Results	Limits Notified by Central Government (CPCB)
1	SO2 (µg/m3)	34	80
2	NO2(µg/m3)	40	80
3	Ozone (µg/m3)	71	100
4	CO2 (ppm)	1500	5000
5	Ammonia (NH3)	240	400
6	CH4 (ppm)	1200	1000

The findings of environmental analysis is summarized in table 9. CH_4 limits are above limits due to the pipe and moisture trap leakages.

Besides the discharge of pollutants into surrounding water bodies, CETP's contribute to anthropogenic greenhouse gas (GHG) emissions into the atmosphere.

V. CONCLUSION AND RECOMMENDATIONS

In order to justify the working and implementation of a CETP the following considerations are to duly noted.

- optimum design
- Minimal cost
- Effectiveness and efficiency
- working capital
- effluent disposal

1. Close analysis and examination of the input must be undertaken. This ensures that there is no anomaly in the working and that the highest factor of reliability is maintained. Prescribed norms and regulations must be strictly followed and at all times by the member facilities.
2. Reduction of sludge is possible and must be entertained in order to increase the active biomass count. This helps in more efficient decay and break down of organic matter. Further, increase in the holding time of sludge must be made possible for the purpose increasing catalytic activity between biomass and organic compounds. This finally enables effective biodegradation.
3. More cost must be charged or incurred by those facilities which has larger quantity of waste generation and subsequently, facilities generating less waste will incur lesser costs.
4. Governing and corrective control is an important parameter of prime importance. Several tools are

available both digital and analog, both online and offline which enable easy governing of the plant facility on the basis prescribed parameters

5. Awareness in the next big step. All the employees and workers and all the concerned human resources must be educated and elucidated with proper awareness and knowledge. This reduces the risk of plant breakdown of any unhappenings affecting the working.
6. This food industryis the perfect example for zero discharge of waste in the environment as it perfectly uses the 3R's waste management.
7. The Life cycle assesment of the plant will help in the analytical results which will ultimately be useful for the operation of effluent treatment plant
8. Approximate Total expense to run CETP per month is around Rs.8,16,500
9. Monthly Cost Saving of Fuel due to Biogas generation is around Rs.35,53,890.
10. Besides the discharge of pollutants into surrounding water bodies, CETP's contribute to anthropogenic greenhouse gas (GHG) emissions into the atmosphere.
11. The emission of GHGs appeared to be highly localised, in that CH4 was primarily emitted from the anaerobic digesters, whereas N2O was primarily emitted from the secondary treatment process involving biological nitrogen removal.

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