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Power efficient treatment of Municipal waste water plants by Biotech approach – a case study.

Article on Energy Efficient wastewater treatment plants

1.0 INTRODUCTION

Continual increases in energy costs affect wastewater treatment plants (WWTPs) just as they do other facilities. Energy costs can account for 30 per cent of the total operation and maintenance (O&M) costs of WWTPs. Furthermore, as populations grow and environmental requirements become more stringent, demand for electricity at such plants is expected to grow .Energy conservation is thus an issue of increasing importance to WWTPs.

Across the nation approximately 23,000 million litres per day (MLD) of domestic wastewater is generated - out of which only 6,000 MLD is treated. The situation is no better in the industrial sector where 1.35 lakh polluting units generate around 13,000 MLD of wastewater of which only 55-60 % is treated. The effluent water treatment norms are getting more stringent thereby throwing open new technological challenges. The Indian wastewater sector was until recently based on low cost model and utilizing outdated technologies - but it is fast evolving while enticing global companies to bring in latest technologies and eager to participate. This scenario reveals the vast, yet untapped, potential in the Indian water and wastewater treatment market - which is set to grow at a compounded annual growth rate of 13 per cent at least until 2013.

2.0 ENERGY CONSERVATION PLANS

Evaluating a facility for energy efficiencies and adopting an energy conservation plan often result in increased treatment efficiency, along with the potential for increased treatment capacity, an increased ability to meet effluent limitations, reduced O&M requirements, and reduced energy costs. Effective energy management plan include:

2.1 Tracking and Evaluating Energy Usage and Costs

The first step in evaluating energy usage and costs at a treatment facility is gaining an under-standing of where the energy is being used. This information allows the WWTP staff to identify areas for conservation and to determine where energy is being used inefficiently.

Once the efficiencies of different pieces of equipment and process operations are determined, the facility can begin to develop energy conservation measures. This assessment will help deter-mine what processes can be modified or what equipment can be operated more efficiently or replaced to save energy.

2.2 Performing Facility Energy Audits

A comprehensive energy audit allows a facility to determine the largest, most energy intensive operations. By determining the energy demands of the various processes and equipment at a WWTP, personnel can look at improving the treatment energy efficiency. The objectives at most facilities are lower energy consumption, demand, and costs. In some cases, life-cycle cost analyses can be used to help assess and optimize the selection of individual components and systems.

2.3 Upgrading Equipment, Systems, and Controls

Numerous processes can be upgraded to improve the energy efficiency of WWTPs. These are as under-

In the activated-sludge process, a higher horsepower surface aerator can be replaced with a lower horsepower subsurface aerator. An aerated grit chamber can be replaced with a vortex system, which can result in energy savings of approximately 70 percent per year. Installing high efficiency influent and effluent pumps, high-efficiency motors, and variable-frequency drives, discontinuing second-stage activated-sludge mixing,

Aeration systems can incorporate high-efficiency motors; variable-frequency drives (VFDs), and dissolved oxygen monitoring. This, in conjunction with energy efficient aeration systems, can provide energy savings of 10 to 25 percent over traditional aeration processes.

Fine bubble diffusers transfer more dissolved oxygen into the water than coarse versions, less oxygen needs to be introduced, lowering the energy required to drive dissolved oxygen compressors. The Fine-bubble diffusers are estimated to save about 2,920,000 kilowatt hours per year.

VFDs enable pumps to accommodate fluctuating demand, resulting in operating at lower speeds and conserving energy while still meeting pumping needs.

Since pump and blower motors can account for more than 80 percent of a WWTP's energy costs and high-efficiency motors are up to 8 percent more efficient than standard motors, it is apparent that high-efficiency motors can contribute greatly to reducing facility energy costs.

Other power saving technologies are use of fuel cells in place of diesel driven generators, investments in energy recovery equipment such as bio-gas-fuelled internal combustion engines, micro turbines, wind turbines, fuel cells, and solar cells.

Installation of an equalization basin allows the plant to even out pumping needs, and so allows for "peak shaving" by running pumps during off-peak hours. Reducing infiltration and inflow in the collection system also can pay for itself in energy savings. By re-habilitating damaged or deteriorated sewer lines and eliminating improper connections to the sys-tem, the overall flow to the WWTP is reduced, thus reducing the amount of energy required to treat the flows.

2.4 Creating the most efficient electric supply purchasing strategy, optimizing load profiles, and reducing costs

A WWTP might be operating equipment when electricity is at peak rates, resulting in unnecessary costs. Plant personnel should become familiar with the energy rate structure to determine whether they can operate equipment at off-peak hours or reduce energy consumption during peak-demand hours.

An example of shifting loads is the use of system storage to store wastewater during periods of highest load rather than operating pumps. The stored wastewater can then be pumped and treated during periods of low demand. A technology often used to supplement energy usage at WWTPs is cogenerating electricity and thermal energy on-site, capturing and using an-aerobic digester gas (or bio-gas).

2.5 Energy Management Education

Employee training and awareness of the energy plan and procedures need to be continually updated to ensure that the goals and energy savings are targeted. Training for plant personnel is essential as is educating the public on energy, efficiency and conservation. A good option for conserving energy at a WWTP is the possibility of reducing flows to the plant by reducing water use in the community. Ideas for promoting water conservation include Educating residents about high-efficiency appliances, plumbing fixtures and water-saving habits, Educating residents to reduce peak water demands to avoid the extra costs associated with operating additional pumps and equipment during peak-flow periods.

3.0 Role of Biotechnology in Energy Management

As we have seen, energy savings in wastewater treatment can be done in a variety of ways. By using the blend of modern technologies and skilled know how of plant operation goes a long way in energy savings. But again, installing latest technologies comes with a cost and there is appreciable increase in CAPEX and OPEX of a project. The investments on power saving techniques is good if the payback period is less and if the payback period is also quite high, we need to seek such technologies which can help in achieving power savings in existing plants without increase in CAPEX and OPEX and without any modifications in the plant.

A major chunk of electricity consumption in a wastewater treatment plant is in the Aeration systems. About 60-70% of the total power consumed in a plant is accounted for running the aeration systems. If the power consumption is optimised in the aeration systems, a lot of energy savings can be achieved. The air requirement in an aeration system which depends on DO levels and BOD loadings can be optimised by continuous monitoring. Excess air supplied to the system needs to be stopped by switching off the aerators or blowers. This process helps in substantial power savings.

Switching off of the aeration systems should be done in such a way that treated water quality is not affected. Fermsept-S is one such biotechnology of Fermenta Biotech Ltd. (FBL) which helps in achieving substantial power savings in wastewater treatment plants without increase in CAPEX and OPEX and without and modifications in the plant. It works under optimum oxygen concentrations i.e. it functions effectively when aerators are switched off. It helps in substantial power savings. Moreover, treated water quality is also maintained within the pollution control board limits by its usage.

Fermenta Biotech Ltd. (FBL) is in the business of biotech products since 1986. Our core expertise is in the field of enzyme biotechnology, critically useful to pharmaceutical and fine chemicals industries. Over the years we have developed very effective environmental solutions using our know-how of enzyme and microbial biotechnology. Our environmental solutions could be used for: Management of industrial waste water and domestic sewage plants (STP's), Nitrification and denitrification problems, Bioremediation of lakes and ponds, ports and harbor, Treatment of oil sludge and waste water in refineries, Solid waste management and soil bioremediation, Handling hazardous waste and management of toxic chemicals, Bio-gas production, to name the few.

Bacteria in FERMSEPT produces various enzymes capable of breaking down complex compounds to simpler ones, hence degrades the organic waste more rapidly and efficiently. By this virtue, it helps to improve the MLSS faster, makes the process more stable and makes the entire system more efficient in STP/ WWTP's. FERMSEPT breaks down and degrade organic & inorganic materials that cause unpleasant odours into odourless compounds. It converts Fats to glycerol and fatty acids, Proteins to amino acids, Cellulose to sugars and Starch to glucose. It breaks "Carbohydrate-Protein-Fat Complex" from the Organo-Inorganic waste mass, extracts nutrients from the digested waste, it multiplies at faster rate than the pathogenic microorganism, hence reduces the disease potential of the waste. It also improves the ratio of healthy versus pathogenic micro flora in favor of development of non-pathogenic bacteria present in it and in the system.

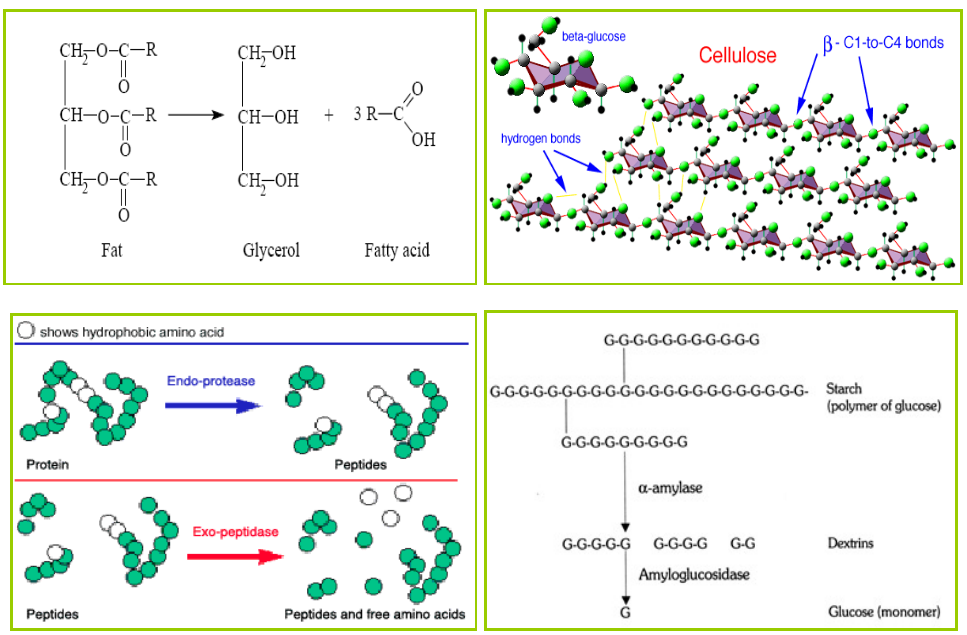

Fig 1: Enzymatic action schematics

FERMSEPT-S also helps in the Reduction of BOD, COD, and TSS within PCB limits, helps in Increase in MLSS / MLVSS, Increases the efficiency of aerobic / anaerobic lagoon & septic tanks. It has the Capability to withstand organic shock loads. It also increases the efficiency of existing plant. It is Eco- friendly. It also helps in Reduction of power cost in the aeration tank, Reduction of capital investment, Reduction in operational cost like nutrients, breakdown cost & manpower cost. Regular use ensures continuous process of digestion, which prevents the accumulation of sludge in aeration tank & polishing pond.

4.0 Case Study of a 30 MLD STP

4.1 Introduction

The case study shows how a 30 MLD STP is saving a lot by using Fermsept-S Biotechnology. The STP is built on a**erated lagoon** concept and based on suspended-growth process treatment unit and maintained by Water Board as deposit contribution work with City Corporation. The aerated lagoon system consists of large earthen lagoons that are equipped with mechanical surface aerators to maintain an aerobic environment for the growth of biomass which will enable the biodegradation of organic matter. It is provided with one raw sewage inlet at one end and gets divided into two parts in Division box and flows into intermediate stage, Eastern aerated lagoon and western aerated lagoon. From these two Eastern & western aerated lagoons, the sewage flows into sedimentation basin through this intermediate stage. Finally the sewage gets polished by retaining the treated water in sedimentation basin for a specified detention time to comply with PCB norms and goes to natural nala through the final outlet. Process Flow diagram is as shown below-

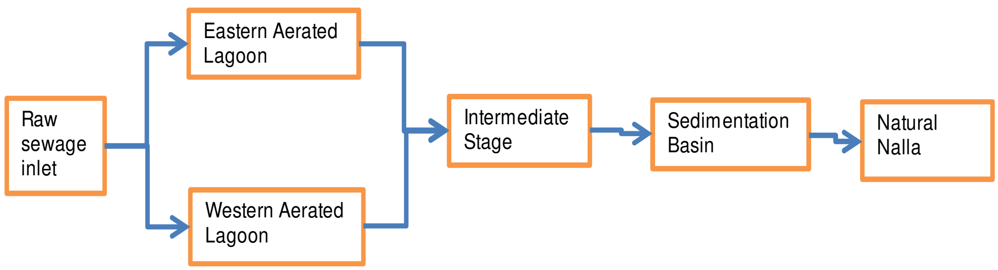

Fig 2: Process Flow diagram

4.2 Design details of 30 MLD aerated lagoon (STP):

- Designed Capacity: 30 MLD (designed upto 2030 population)
- Current inflow of Raw sewage : 22 MLD
- Year of commissioning: December 2004
- Type of treatment:
  - Primary treatment (grit chamber)
  - Aerated Lagoon
  - Sedimentation Basin
- No of aeration tank: 2 Nos,
- No of aerators: 27 Nos,
- Total volume of lagoons: 2,29487.54 m3
- No of sedimentation tank: 2 Nos.
- Total volume of sedimentation basins: 45178.74 m3

4.3 Situation before the application of biotechnology in 30 MLD STP:

- High utility cost to comply with PCB norms.
- High utility cost like power, manpower & repairs of aerators.
- Huge accumulation of sludge in both aeration tanks would reduce the detention time and the sludge would release the pollutants like nitrogen & phosphorous and which in turn will increase the BOD, COD & TSS parameters in outlet water. This requires emptying of aerated lagoons, diversion of sewage, cleaning of tanks and disposal problems. Therefore it is mandatory to clean these tanks once in 5 years and would incur huge cost to clean up and create secondary pollution problems during disposal.
- Capital cost required for upgradation of STP.
- Regular break down, wear & tear of surface aerators.

4.3.1 Parameters before the application of biotechnology:

Table 1: Water quality parameters before application

Sr.No	Parameter	Raw influent	Outlet no.1	Outlet no.2	PCB Limits
1	pH	7.66	7.6	7.72	6-9
2	BOD in ppm	318	256	256	Max 20
3	COD in ppm	865	720	712	Max 250
4	TSS in ppm	240.5	82	88	Max 30

Water quality parameters are shown in the table above. BOD at the outlet was in the range of 250-300 ppm and COD was in the range of 700-750 ppm before the application of the product. TSS was also around 80 ppm.

4.3.2 Power charges calculations.

The theoretical power consumption (KWh) of aerators in the lagoons can be calculated by knowing the actual running hours (hrs) and HP or KW rating of the motors. This can be multiplied by the number of aerators and unit rate for cost calculations on daily, monthly and yearly basis. Assuming, power cost of aerators cover 60% of the total plant power cost, operation cost details are given as percentages of the aerator power cost.

Table 2: Total cost of operation before application

Cost of operation before the application of the product addition:	For 1 year
Cost of power before the addition of biotech product with the optimization of aerators	60% of total power cost
Cost of sludge removal in the aerated lagoons:	36.46% of aerator power cost
Cost of repair of surface aerators :	22.60% of aerator power cost
Cost of establishment/manpower:	52.55% of aerator power cost
cost of chemicals for the analysis of untreated/treated sewage :	0.30% of aerator power cost
Total cost of operation for 1 year :	Sum of all the above items

The treatment of sewage using biotech product Fermsept –S was taken up to establish the following;

- Whether biotechnology can bring down the treated water parameters like BOD, COD & TSS within KSPCB limits without additional capital expenditure?
- Can this technology work in aerobic and anaerobic conditions?
- Can this technology bring down capital cost and operational cost?

Below mentioned were the objectives discussed before the demonstration of the biotech product Fermsept® - S;

- Reduction of BOD, COD & TSS within PCB limits without any additional capital expenditure.
- Increase the efficiency of existing plant without any upgradation cost.
- Reduction of power cost in the aerated lagoon by switching of aerators.
- Reduction of capital investment like space, civil cost and surface aerators in the future projects.
- Final treated water can be reused for irrigation purpose and industrial application.

- Reduction of operational cost like repairs & manpower.
- Reduction of sludge removal cost which is mandatory once in 5 years.
- Establish the methodology to use the biotechnology in FAL, aerated lagoon and activated sludge process.

4.4 Parameters after the application of Fermsept®-S:

Table 3: Water quality parameters after application

Date	26-05-2011			10/12/2011			27-06-2012		
Parameter	Inlet	Outlet no.1	Outlet no.2	Inlet	Outlet no.1	Outlet no.2	Inlet	Outlet no.1	Outlet no.2
pH	7.1	7.58	7.46	6.82	7.24	6.9	7.2	7.52	7.46
BOD(ppm)	320	16.5	14.5	240	12.9	14	173	20	18
COD(ppm)	883	62.3	42.8	1036	39.8	35.8	391	71.1	87.9
TSS(ppm)	172	6	10	80	18	4	42	28	28

After application of product, BOD at the outlet was in the range of 10-20 ppm and COD at outlet was in the range of 30-60 ppm. TSS levels were also reduced to near 10 ppm. The product is thus helpful in meeting the PCB norms apart from power savings. The BOD reduction trend is shown as below.

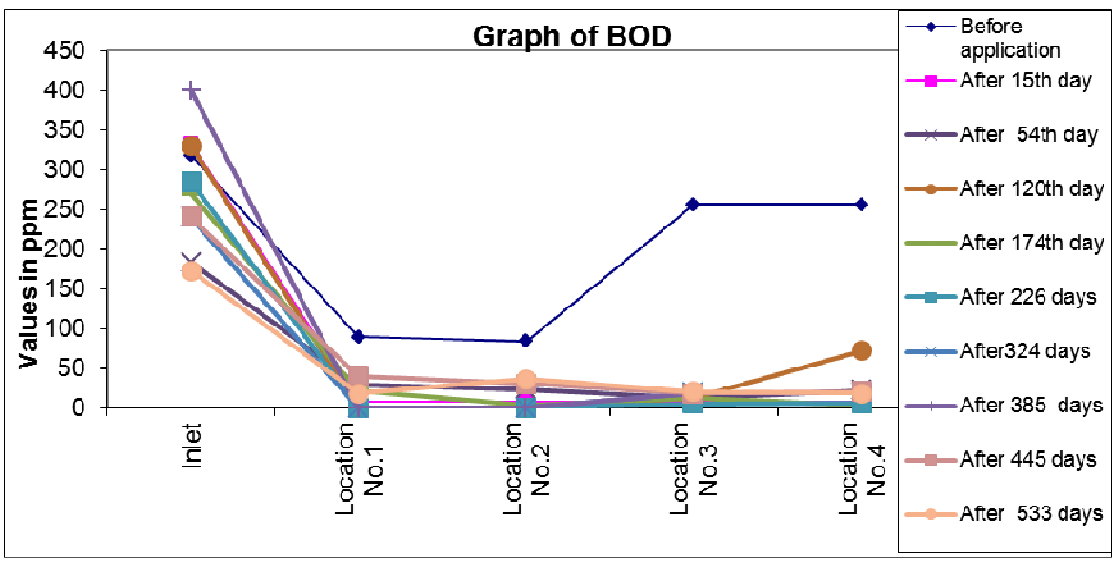

Fig 3: BOD reduction trend across different locations

The COD reduction trend is shown as below.

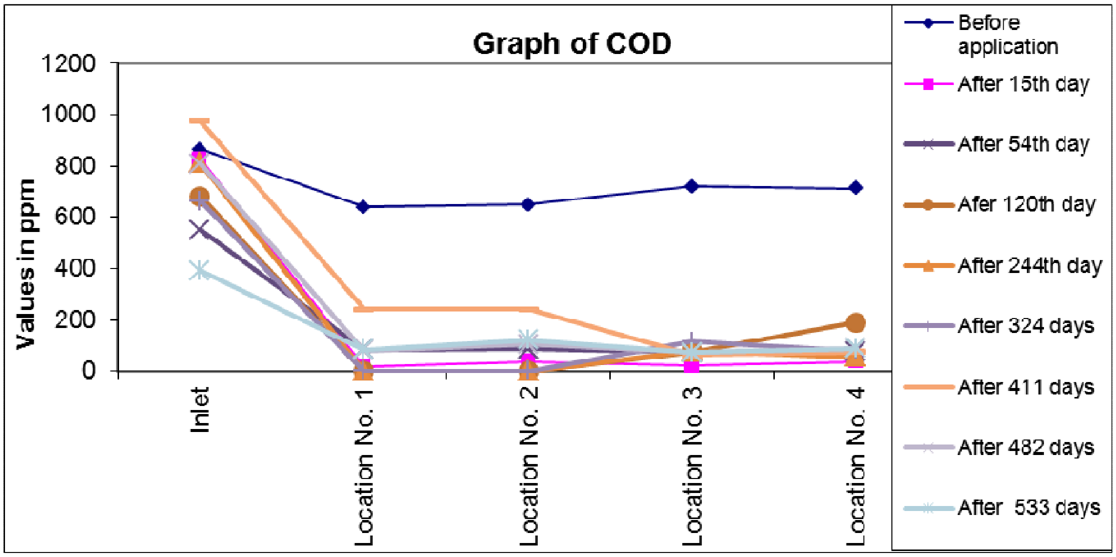

Fig 4: COD reduction trend across different locations

BOD and COD removal efficiencies

Overall effect on % BOD and COD removing efficiency by using Fermsept-S has improved. The percentage removal of BOD and COD has increased after the application of the product. Now, more than 90% BOD and COD removal efficiency is being achieved which was initially only 10-20%.

4.5 Power consumption data after the application of biotech product Fermsept- S;

The graphs below show the average power consumption and monthly power consumption. The data shows that 70 % power savings are achieved till date.

Effect on power consumption after Fermsept S application at STP

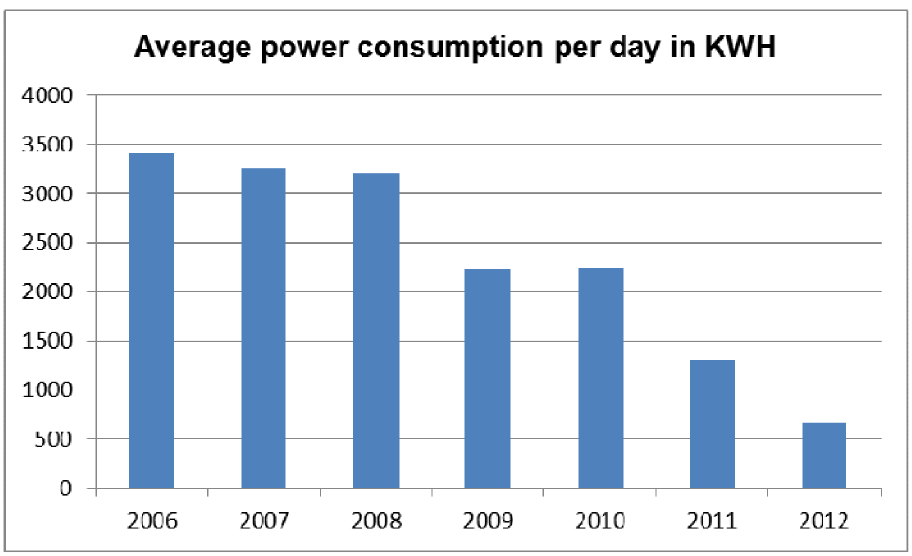

Fig 5: Average power consumption per day

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Monthly Power consumption graph at STP after Fermsept-S treatment

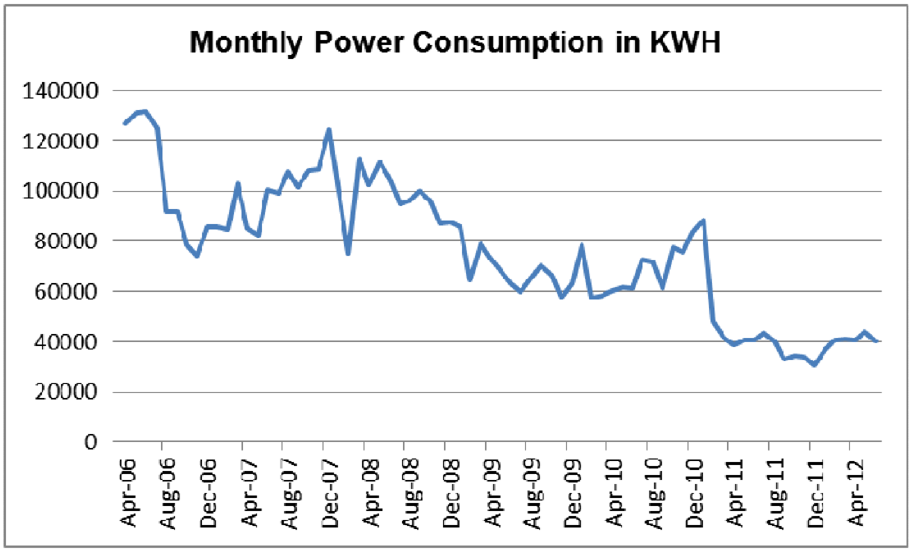

Fig 6: Trend of monthly power consumption

Saving on power consumption – After the application Fermsept-S:

Table 4: Total cost of operation after application

Cost of operation after the application of the product Fermsept-S:	For 1 year
Cost of power after the addition of Fermsept:	45.38% of initial cost before application (Table 2)
Savings on sludge removal from aerated lagoon cost:	Nil.
Cost of repair of surface aerators :	17.42% of aerator power cost
Cost of establishment/manpower:	66.39% of aerator power cost
cost of chemicals for the analysis of untreated/treated sewage :	0.66% of aerator power cost
Cost of the product Fermsept®-S for 1 year:	Actual product cost
Total cost Total cost of operation for 1 year :	Sum of all the above items

4.6 Cost Benefit analysis of Operation cost:

Considering, the total operational cost before and after application of biotechnology, approx. 35-40% savings have been achieved.

Apart from the above said advantages, savings, Management of STP and City Corporation will generate more revenue by the sale of 18.5 MLD of treated sewage to sponge iron plants in City though allotment process. The allotment process is already completed to sell the water which will further add the profit percentage.

Application of Fermsept-S at STP has substantially reduced power consumption and 60-70% power savings have been achieved. Moreover, water quality parameters such as BOD and COD have reduced drastically and brought under the norms of PCB. Therefore, the Power saving model is validated by achieving power savings as well as maintaining the water quality parameters within the norms.

5.0 Conclusion

Thus we have seen that if there are alternatives which can reduce the energy consumption of WWTPs without investments in CAPEX and OPEX, and keep the water quality parameters within the norms, such alternatives should now be looked at. Fermsept-S is such a biotech product which helps in energy conservation as well as environmental management.

References:

1) United States Environmental protection Agency (USEPA)

2) Project Vendor Magazine

3) FBL Data bank