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ENERGY-EFFICIENT AND COST-EFFECTIVE SEWAGE TREATMENT USING PHYTORID TECHNOLOGY

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Abstract - The process of design, construction and operation of sewage treatment plant (STP) requires multi-disciplinary approach. Numerous conventional methods are available for design of sewage treatment plants. The process involved in these treatments is either aerobic, anaerobic or combination requiring number of mechanical and electrical items thereby requiring substantial energy. The ever growing need of energy makes the design, operation and maintenance of STP a challenging task. The conventional method of sewage treatment can be made efficient by advanced technologies and intelligent supervision but this in turn increases the total cost. However, root zone technology developed by National Environmental Engineering Research Institute treats the sewage by phytorid plant. It is found from the study carried out on nine STPs at various locations in Pune and Mumbai in Maharashtra (India) that the sewage treatment by phytorid technology uses only 20% of the energy as compared to conventional sewage treatment plants. It is thus concluded that phytorid technology is the future for sewage treatment.

Keywords: *sewage treatment plant, aerobic, anaerobic, phytorid.*

I. INTRODUCTION

Primary water source is polluted to a great extent through discharge of harmful substances. It is estimated that every 1 m^3 of contaminated water once discharged into water bodies will contaminate further 8 to 10 m^3 of pure water. Out of the 31 diseases that are major cause of death in developed countries, as many as 21 are due to contaminated water. The above facts highlight the need to find improved water treatment to meet the problems of food security, water availability and use of water efficiently. It is beyond any doubt that energy will be the main concern of the nations in coming years. Identification and adoption of appropriate technology to overcome these pressures is therefore absolutely essential.

The object of sewage treatment is to stabilize the organic matter present in sewage so as to produce an effluent liquid and sludge, which can be disposed-off into the environment without causing health hazard or nuisance. The endeavor should be to adopt modern and cost- effective technologies and equipment to achieve value for money and maximum user satisfaction. The septic tanks which treat the sewage by pure anaerobic process can be considered as preliminary STP. The requirement for better treatment of sewage coupled with development of technology lead a way forward towards aerobic process. This requires pumping and blower operation which is energy consuming. Thus conventional STP requires energy for achieving better results .The aerobic process requires oxygen to be provided to the bacteria. Chong *et al.* [1] discussed the recent developments in photo catalytic water treatment technology. The ability of this advanced oxidation technology has been widely demonstrated to remove persistent organic compounds and micro-organisms in water. Novak and Horvat [2] discussed the structured mathematical models which combined the use of oxygen electrode and biological waste water treatment to optimize the position of electrode in the bio-reactor for efficient transfer of oxygen. The ever-growing need of energy makes the design, operation and maintenance of STP a challenging task. Poch *et al.* [3] deliberated on improvement of conventional wastewater treatment through an intelligent integrated supervisory system. Recently developed concept of treating the sewage by root zone technology provides aerobic and anaerobic treatment simultaneously in one tank. Yang [4] used phyto-remediation for treating contaminated site and concluded that it is an efficient, economical, and environment friendly eco-technology. Besides these advantages, phyto-remediation has considerable potential for environmental restoration of contaminated sites. Pawaskar [5] has suggested modification in root zone technology that overcomes the limitation of huge area requirement for application of constructed wetland (CW). The modified CW can be effectively used within the nallah area to treat incoming waste water with techno-economical feasible option. Vymazal [6] discussed that horizontal sub-surface flow constructed wetlands in the Czech Republic are designed to take an advantage of many of the same processes that occur in natural wetlands. The results of the observations by the author also indicate that constructed wetlands can be used as tertiary treatment systems to polish organics and suspended solids. Zhang *et al.* [7] carried out comparison between the cost of a conventional wastewater treatment processes and CW. The results showed that the CW does not have any advantage in construction cost. However, it has advantage in operation and maintenance cost. The operation and maintenance cost of conventional plant was found to be Rs 16/m^3 whereas CW was Rs 1/ m^3. The main objective of this study was to identify energy-efficient design parameters for a conventional STP and comparison of construction, operation and maintenance cost of STPs vis-à-vis sewage treatment by phytorid technology. Based on the different systems and technology, nine STPs were visited for the study. The emphasis was on construction cost along with operation and maintenance aspects.

II. MATERIALS AND METHODOLOGY

The visits to the STPs having different capacities and different systems were made to study and compare the construction, operation and maintenance costs. The study included (i) process employed (ii) initial cost of construction (iii) maintenance costs and (iv) usage of treated waste water. The emphasis was given to maintenance cost considering electrical load and chemicals used. The norms and guidelines of Central Pollution Control Board were taken into account during the study. Energy efficiency parameters were identified and comparisons made to arrive at the best fit solution. The visits to the STPs and material received have helped in deducing the following energy-efficient design parameters which dictate the energy requirements:

(i) Pumps-The aerobic, anaerobic or any other combination system of STPs require pumps for operation. Besides there is a requirement to run the pumps continuously either for raw sewage, sludge or filter water, etc. Thus the main consumers of electricity are pumps.

(ii) Blowers-The maximum energy is consumed by blowers since they are of higher ratings and run 24 hrs.

(iii) Diffusers-These are the network of pipes laid in the tanks having holes of various sizes and alignments. The efficiency of the system depends on the matrix of holes which in turn dictates energy consumption.

(iv) Media - The consumption of energy and efficiency in STP depends on the surface area and typical media used for bacterial growth. Moving media bio-reactor will use less energy compared to activated sludge.

(v) Chemicals - These are required for flocculation, coagulation and disinfection. The use of chemicals contributes towards cost.

(vi) Advanced Oxidation Process - Employs ultraviolet radiation for efficient oxidation but requires substantial electricity consumption.

(vii) Automation - It achieves intelligent supervision for efficient operation and maintenance of sewage treatment plant.

(viii) Operator- The human element is irreplaceable. However some systems like phytorid requires less supervision.

RESULTS AND DISCUSSIONS

The cost of construction depends on the availability of existing facility for treating the sewage *i.e.* septic tank, type of construction (over ground/underground) and type of material. The cost is also governed by degree of treatment desirable *i.e.* primary, secondary or tertiary. The data obtained from the STP sites are as shown in Table I, II, and III. It is observed from Table I that the cost of construction of aerobic and anaerobic STP is generally the same. The average cost of construction/m^3 is Rs 15-20. However, cost of STP using phytorid technology is on higher side since the structure is bigger requiring more space.

The operation and maintenance costs depend on the type of system employed in STP *i.e.* aerobic, anaerobic, combination of both and phytorid. It can be seen that the operation & maintenance cost is very high for aerobic and anaerobic STP and maximum being for combination of aerobic and anaerobic (Rs 3000/day). However, it is least in case of phytorid.

The design parameters such as pumps, blowers and ozonation unit required for a typical STP has been studied for connected and consumption load as seen in Table II. It can be seen that the cost of O & M depends on the number and type of electrical and mechanical equipments installed and duration of work. The cost is also contributed by usage of chemicals especially in anaerobic STP. Table III gives the O & M cost of STP which includes cost of electrical load as well as chemicals for a 200 m^3 capacity. It is observed from Table III that the cost of operation and maintenance per day of the conventional aerobic and anaerobic STP is Rs 1600 and Rs 2700 respectively. However the cost of operation and maintenance of STP on phytorid technology is just Rs 200/day. In order to understand the implications of O & M costs in the longer run say for 25 years, annual costs O & M are determined and displayed in Table IV. The Table IV clearly depicts that the percentage saving in operation and maintenance cost of STP by phytorid te[illegible] 1063 [illegible]s 80% with respect to aerobic process and [illegible] with respect to anaerobic process. Thus phytorid technology is best suited from the aspects of energy saving maintenance aspects.

TABLE I CONSTRUCTION AND OPERATION COST OF STP

Sr No	Treatment process	Capacity (m^3)	Construction cost (Rs)	Operation cost/day (Rs)
1	Combination	250	31,00,000	3000
2	Combination	100	27,00,000	2700
3	Aerobic	200	32,50,000	1500
4	Aerobic	100	35,00,000	1200
5	Anaerobic	250	37,00,000	2800
6	Anaerobic	250	38,00,000	2900
7	Anaerobic	100	30,00,000	2000
8	Phytorid	50	30,00,000	120
9	Phytorid	500	90.00,000	200

CONCLUSION

Detailed study was carried out on the STPs employing different process system and the comparisons were made categorically on the construction and operating cost. The emphasis was given on maintenance cost considering the electrical load and chemicals used. The conventional type of STPs employing the aerobic, anaerobic or combination of both can be made efficient by advanced technologies and intelligent supervision but this in turn increases the total cost. The entire problem of energy requirement, maintenance and supervision in conventional STPs is saved by adopting phytorid technology. The conclusions drawn are as under:(i) The cost of construction of STPs of various technologies is almost same.(ii) However, the maintenance cost varies significantly among aerobic, anaerobic and phytorid technology. Sewage treatment by phytorid technology uses only 20% of the energy as compared to conventional sewage treatment plants.(iii) The details gathered and enumerated in table of comparisons points to clear choice of phytorid technology as the STP of future

TABLE III DAILY COST OF OPERATION AND MAINTENANCE OF STP (200 m^3)

Process system	Consumption (kWh)	Unit cost (Rs)	Total consumption (Rs)	Cost of chemicals (Rs)	Total cost (Rs)
Aerobic	150	10	1500	100	1600
Anaerobic	120	10	1200	1500	2700
Phytorid	15	10	150	50	200

TABLE IV ANNUAL COST OF OPERATION AND MAINTENANCE OF STP (200 m^3)

Process system	Construction cost (Rs)	Operation & maintenance cost (Rs)
Aerobic	35,00,000	5,50,000
Anaerobic	33,00,000	9,85,000
Phytorid	43,00,000	1,10,000

Item	Connected load			Consumed load			
	Power (kW)	Units	Total (kW)	Power (kW)	Units	Run (hrs)	Total (kWh)
Settling tank feed pump	2.00	2	4.00	1.50	1	22.00	33.00
Flocculent dosing pump	0.50	1	0.50	0.37	1	22.00	8.21
Coagulant dosing pump	0.50	1	0.50	0.38	1	22.00	8.25
PSF feed pump(Blower)	3.00	2	6.00	2.25	1	22.00	49.50
Oxidant dosing pump	0.50	1	0.50	0.37	1	22.00	8.21
Energy activation and detoxification unit (Ozonation unit)	3.68	1	3.68	2.75	1	22.00	60.40
Backwash pump	3.00	1	3.00	2.25	1	0.5	1.13
	Total connected load		18.18	Total consumed load			168.68

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