

Common Effluent Treatment Plants

Technology & Treatment Process: The Alternative Strategies

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Society for Voluntary Action,
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Abstract

Svaraj's working papers aim to highlight the concerns and issues being raised from our programme partners, and to engage stakeholders in working towards appropriate solutions.

Industrial pollution has become one of the most pressing issues in India. The MoEF estimates that industries contribute to more than one third of the total pollution in rivers and other water bodies. The treatment capacities available, for an average of 13000 MLD of industrial waste that is generated, amounts to about 8000 MLD.

This paper addresses the inability of most current treatment practices to effectively treat wastewater. The main factors responsible for the limited success of common effluent treatment are identified and means to improve the situation are surveyed.

Factors that determine the choice of technology differ for every type of wastewater treatment plant. Effluents have to be subjected to certain minimum levels of treatment for achieving the desired quality of water that is disposed or reused. The paper outlines these aspects, which have to be recognized in order to design a treatment process that can satisfactorily treat effluents to meet the prescribed standards.

Svaraj and the Swedish International Development Agency (SIDA)

Svaraj's water programme, developed with, and funded by the Swedish International Development Agency (SIDA), is a community centered, water resource management programme. At Svaraj we believe that, by putting communities' center stage in the water debate, we are capacitating individuals to effectively and equitably manage their own water needs. Svaraj's water programme currently operates in South India. Through our program work, policy debates, and working papers, we aim to mobilise different sectors of the community to debate the issues that affect them.

The Current Scenario

Common effluent treatment plants (CETPs) were perceived to be a feasible solution for abatement of industrial wastewater pollution. However complexities involved with practical application and logistics proved not to be as appealing as the abstraction.¹

Segregation and pretreatment of influents is imperative for CETPs that cater to more than one kind of industry. Characteristics of effluents have to be tailored to bring it in congruence with wastewater being sent in from other industries (Refer Table 1). For example the wastewater from

electroplating industries might be low in quantity but is highly toxic and hazardous in nature and can be even lethal when contacted. Mixing this with effluents from other industries such as textiles and pharmaceuticals, which discharge a large amount of

The Limited Success of CETPs

'After a recent inspection by the SCMC (Supreme Court Monitoring Committee) a letter was sent to the DSIDC (Delhi State Industrial Development Commission), which warns that unless the industrial units comply with all the norms by October 15, "all those individual units contributing to specific CETPs will face closure". While the Capital boasts of 10 CETPs, the working of these plants have been far from satisfactory' - The Hindu (Aug 06, 2004), on CETPs in New Delhi

"The data on CETPs supplied by the Board during the SCMC's visit is not adequate in terms of treatment system place, performance of the units and the characteristics of final treated effluent." - Report of the visit of the SCMC to Tamilnadu (September 20-22,2004)

"The committee has pointed out that nearly 73 industries are discharging their wastewater directly or indirectly (through drains) to the river. Of this, only 47 industries have ETPs among which only 22 industries meet the prescribed standards'- The Statesman (24 September 2000), with regard to 'The Kaul Committee' report on Control of Pollution in Kali Nadi Basin.

1. For more information on CETP policy and practice refer to Working Paper Series No. 1 titled 'Rivers of Waste: Industrial Pollution; Rethinking Policy and Practice'.

The simultaneous treatment of intrinsically different contaminants may not be possible due to the ability of treatment equipment to treat only a particular range of influents. However, firms have been lax in setting up pretreatment units and segregating wastewater as it imposes operational costs on them. A failure to consider the differences in wastewater and nonobservance of the prerequisites has only aggravated the pollution situation in certain cases. A study on water pollution in Tiruppur showed that most of the parameters (except for pH and sulfate) of treated effluent that was discharged from 8 CETPs increased after treatment.²

Another repressive feature of CETPs is the constant variation in the volume of influent. The performance of 52 CETPs operational around India during the year 2002-03 was surveyed by the CPCB3 (Central Pollution Control Board). One of the main observations was that the average inflow in 41 CETPs was in the range of 25-65% of the design capacity and only 11 CETPs were receiving more than 90% of the design inflow quantity of industrial effluents. Treatment plants lose their effectiveness when constantly used to treat a volume of effluent that is much below its designed capacity. Most CETPs are not designed to accommodate unexpected changes in volume of effluent, which causes operational problems that affect the functioning of the plant. The CPCB study also stated that the effluents discharged by all the 52 CETPs were not compliant with the prescribed standards (Refer Table 2).

The incapacity of CETPs to cope with uncertainties associated with combined treatment demands more intensive and comprehensive planning (Table 3). Each component of the CETP needs to be scrutinized in the milieu of numerous factors and not as a single entity. Coordinating the entire assemblage raises the demand for a multi-dimensional approach that involves proper management and practical decision-making processes.

A survey conducted by CPCB 1994-95, on wastewater treatment indicated that, the facilities constructed to treat wastewater did not function properly most of the time due to improper design and

Table 1: Inlet Effluent Quality Standards for CETPs

Parameter	Concentration
pH	5.5 - 9.0
Temperature (⁰ C)	45
Oil and grease	20
Cyanide (as CN)	2.0
Total chromium	2.0
Lead	1.0
Arsenic	0.2
Mercury	0.01
Cadmium	1.0

Note:

a. For each CETP and its constituent units, the State Board will prescribe standards as per the local needs and conditions; these can be more stringent than those prescribed above.

b. Concentrations in mg/L except pH & Temperature or otherwise specified

Source: The Gazette of India: Extraordinary-Part II- Sec.3 (i) PP 10 Dt.27th Feb 1991

poor maintenance, together with a non-technical and unskilled approach.

Table 2: Treated Effluent Quality Standards for CETP

Parameters	Into Inland Surface Water	Public Sewers	Into Marine Coastal Areas
pH	5.5 - 9.0	5.5 - 9.0	5.5 - 9.0
BOD 200C	30	350	100
COD	250	-	250
Oil & grease	10	20	20
Dissolved solids (Inorganic)	2100	2100	-
Total residual chlorine	1.0	-	1.0
Suspended solids	100	600	a. Process wastewater -100 b. Cooling water (CW) effluent 10% above total suspended matter of influent CW.

Note:

a. Concentrations in mg/L except pH & Temperature or otherwise specified

Source: CPCB.2001.Pollution Control Acts, Rules, and Notifications issued there under (4th edition, pp.358-359). New Delhi: CPCB, MoEF, GOI. 897 pp.

2. Refer to: - Economic Assessment of Environmental Damage: A Case Study of Industrial Water Pollution in Tiruppur; By Paul .Appasamy with Prakash Nelliyyat, N.Jayakumar and R.Manivasagan; Madras School of Economics, Chennai. URLhttp://coe.mse.ac.in/eercrep/abs/appasamy_abs.pdf

Table 3: Status of wastewater generation (w/w), collection, and treatment in class I cities and class II towns (mld- million liters pre day)

Type, Number of cities/towns	w/w generated (mld)*	w/w collected (mld)	% w/w collected	w/w treated (mld)	% w/w treated (of collected)	% w/w treated (of total)
299 Class I cities	16662.5	11938.2	72	4037.2	33.8	24
345 Class II towns	1649.6	1090.3	66	61.5	5.6	3.7
Total - 644	18312.1	13028.5	71	4098.7	31.5	22.4

Key: *Also includes information gathered on industrial wastewater

Source: CPCB 2000a. Data compiled from <http://www.nrel.gov/docs/fy03osti/30383.pdf>

Process of Treatment

The level of treatment that wastewater is subjected should be determined by the purpose for which it is recycled. It can either be discharged in water bodies or reused for other purposes such as drinking and gardening, depending on the quality produced. However it should be treated up to certain minimum levels in order to free the water of harmful contaminants that pollute the receiving environment. The treatment process is a multifaceted task that needs to be planned and controlled in a sequential manner in order to meet the required discharge standards.

Plant designs are tailored to meet specific demands of the wastewater to be treated and its environment. Hence there is no set format that can be applied for the treatment of various effluents originating from various industrial and domestic sources. Below is the general overview of the various procedural steps.

- 1) Primary Treatment** - involves the removal of suspended solids, oils and coarse fractions, which could damage and interfere with downstream equipment. It alters characteristics of the wastewater through chemical addition to meet the needs of the ensuing treatment processes.

i) Preliminary Treatment removes large floating materials (like rags, plastic, and construction debris) along with other heavy particles through screening machines, grinders and grit chambers.

ii) Primary Clarifiers are settling tanks that separate the suspended solids from the primary effluent. The wastewater is also flocculated with additives like polymer and alum to fasten the settling process.

- 2) Secondary treatment** - is the biological degradation of organic material. This process usually decontaminants water to the extent that it can be directly discharged to percolation ponds, which are less vulnerable than the natural environment.

i) Aeration tanks maintain microorganisms that consume the organic material for their enzymatic activities. As a result the influent is purified of soluble biodegradable material. Oxygen is infused to energise microorganisms, either through surface aerators (e.g. mechanical propellers) or diffused aerators (which are submerged machines).

ii) Secondary clarifiers are sedimentation tanks for the activated sludge, which are also used for flocculation. Secondary sludge contains microorganisms that are washed out with the contaminants. A certain volume of sludge, referred to as 'return activated sludge' (RAS), is redirected to the aeration basins, for reusing the surviving microorganisms. The remaining 'excess activated sludge' (EAS) is sent to the sludge-handling unit.

- 3) Tertiary treatment**- refurbishes the product to produce water that can be safely released to water bodies. Approximately 95% of the impurities are removed at this stage. The influent is first disinfected with chlorine, oxidants, or ultraviolet light irradiation. Filters such as sand, micron and active carbon are used to absorb excess chlorine, color and organics.

Membranes are pressure dependent processes that can stand varying operating conditions. They are capable of separating all types of suspended and dissolved inorganic and organic contaminants. Membranes such as micro filtration (MF), ultra filtration (UF) and nano filtration (NF) have varying pore sizes, which determines the extent to which contaminants are removed.

- 4) Polishing unit**- is used only when the recycled water is used for purposes that require very safe and high quality water. It can produce ultra pure water, which is defined as water that is either free or has a very low content of particles, organic and colloidal matter.

4 See: - Management of Freshwater Resources. URL -http://envfor.nic.in/soer/2001/ind_water.pdf

i) **Reverse osmosis (RO)** is one of the examples of a polishing device. It is an advanced form of membrane technology used to purify water for drinking purposes. It is a costly unit to maintain due to its high-energy requirements and requires extensive pretreatment of the waste water, as it is easily susceptible to damage

5) Sludge Management- The sludge, mainly composed of water, is thickened, stabilised, dewatered and disinfected before it is disposed. Depending on the wastewater that is treated, sludge can contain substances that are harmful to the ecology such as heavy metals and chemicals. Therefore it cannot always be disposed off through incineration and landfills or even reused in any form.

Depending on the wastewater and the technology used in a particular plant, some of these steps might be omitted or be unnecessary. For instance wastewater from an electroplating industry contains only inorganic contaminants. Therefore secondary treatment, which is used to treat only the organic wastes, will not be included for the treatment process. Also filters can be excluded when certain membranes are used, and primary treatment need not always include clarifiers or chemically modify influents.

Directives for the Appropriate Selection of the Treatment Process and Technology

Selecting the right mode of treatment is of great consequence in any wastewater management strategy. Every CETP is faced with a set of challenges and characteristics that are unique to its location, size, type of wastewater to be treated etc. As an example, the difference in availability of factors of production from location to location could be the main determinant for the different choice of equipment in two plants. A technologically advanced unit with low labour requirement will, ideally, be favoured over a labour intensive unit, in an area characterized with labour shortage or capital abundance.

Negligence of a few crucial criteria could justify the failure of a CETP. The following is a broad classification of a few of the common factors that have to be considered while designing the treatment process: -

Characteristics of the effluent:

- Type of contaminants
- Concentration of contaminants
- PH, temperature
- Turbidity
- Bio degradability
- Solids content

Suitability of treatment equipment:

- Affordability
- Energy efficiency
- Versatility-range of contaminants that can be treated
- O&M requirements
- Labour requirements
- Life length of the equipment

Operating conditions to be handled by the plant:

- Scale of operations-type, size and number of industries to be catered to
- Plant design-ability to accommodate for variations in volume
- Flexibility-allowing for future modifications and additions or subtractions in capacity
- Location and site characteristics Availability of space
- Energy requirements: including source and availability
- Distance over which wastewater has to be transported from the industry

Financial Considerations:

- Capital costs- cost of setting up the infrastructure, price of treatment units, cost of land etc.

- O&M or working costs- cost of energy, chemicals, personnel, servicing of units, replacements etc.

Each of these factors has to be scrutinized in the context of a specific plant. A factor that is important to one plant may not be a priority for another. For example in a CETP, which caters to several different industries, there has to be a greater emphasis on capacity handling. In order to overcome this problem a CETP might prefer, as an example, to build several small aeration units instead of one large unit. This way the change in volume of effluents will not affect the entire aeration unit and only some of the tanks will be put out of use. Since the ETPs that cater to one industry do not experience drastic changes in the quantity of effluent, planning the size of the plant is a question of basic mathematics.

Case Study: Determining the Choice of Treatment Process and Technology

The two sewage plants elucidated for the case study are: - the Bangalore Development Authority (BDA) treatment plant in Cubbon Park, and the on-site ETP set up by MICO Bosch.

Owned by	BDA	MICO Bosch
Design Capacity	1.5 ml/d	.25 ml/d
Average Flow/Quantity	Within designed capacity	.18 – 0.22 ml/d
Source of Wastewater	BWSSB sewage	MICO
MLSS for Aeration	6-12 gm/lit.	4-5 gm/lit.
Cost of Treatment	NA	0.06 paise/liter
O & M Requirement	UF membrane to be cleaned and serviced (for a max of 2times a year)	Sludge manually removed every 3 days;O&G (Oil and grease) manually removeddaily
Energy Source	Electricity	Electricity
Labour Requirement	Low- fully automated plant	Manual removal of O&G and sludge.
Application of Treated Water and Sludge	Toilet flushing and gardening for surrounding buildings.	Toilet flushing and gardening on campus. Sludge cakes used as manure for the gardens.

Note: O&M- Operation and Maintenance; ml/d- million liters per day; MLSS- Mixed liquor suspended solids; gm/lit.- grams per liter; NA- Not Available

Source: Svaraj

The BDA plant features the technologically advanced membrane bioreactor (MBR), which incorporates a submerged UF membrane. It replaces the conventional activated sludge (CAS) treatment by combining clarification, aeration and filtration (Refer Figure 1)

This makes it a compact unit that is most suited for areas with space constraints, like crowded urban areas. It also allows for convenient modifications of the plant capacity in the case of variations in effluent quantity, as membranes can be added in modules. Due to the automated controls, labour requirement and supervision along with maintenance will be at its lowest. On an average there is 1 mechanical/electrical fitter per shift and minimal manual labour for housekeeping.

Although not conclusive, research studies reveal that MBRs produce a higher quality of water than the

CAS process, which is especially low in COD, solids, organic suspensions, turbidity and pathogens. As membranes also prevent the waste-consuming microorganisms from passing through, higher concentrations of MLSS (mixed liquor suspended solids) can be maintained. The higher MLSS, which averages around 10-20 gm/lit. for a typical MBR as against 2-3 gm/lit. for CAS, fastens the degradation of organic wastes. Although this feature may raise the requirement and costs of oxygen transfer it also circumvents the need for a return activated sludge pipe.

Although limited in number, the majority of MBR systems around the world have been installed in industries such automotive, metal fabrication, food processing etc. and also used for treating landfill leachate. This fact portrays not only its versatility but also its potential capacity. However, at present, the municipal plant (Cubbon Park) being the first of its kind to install an MBR in India raises doubts about its commercial/financial viability in India in the near future. Besides the capital costs, even the working costs in terms of energy requirements, pretreatment devices and replacements could be a substantial figure. Local availability of the product is very low and importing the product will only add to the already forbidding costs.

The solution lies not only in adopting cost effective and advanced technology but also placing them in the right environment. The plant must be financially and logistically capable of providing the required energy, labour, technical support and maintenance. Neglecting the operation and maintenance (O&M), which includes pretreatment of influents, servicing and cleaning, can reduce plant life by 50 to 60% and incapacitate the units.

In a situation when financial resources and local manufacturing capability is low along with a paucity of technical and skilled labour support, a conventional treatment process such as the one set up at MICO may be a better and more feasible solution (Refer Figure 1 for process of treatment). The treatment is energy-efficient, as the only energy consuming activity is the aeration process. This will further reduce if the surface aerator is replaced by a diffused aeration system. However diffused aerators are more expensive to install and have greater maintenance costs than surface aerators. The labour requirement is usually higher for a CAS process. But in areas with a large supply of manpower, even a high input of human resources will not occupy a major portion of the budget. The MICO plant employs approximately 7 staff members, functioning as supervisors, housekeeping personnel and labour for removal of

sludge (approx. 100kgs/3 days) and oil & grease separation. Although the requirement of manual labour and supervision might be higher, both capital costs and working costs might be lower than advanced processes. Not only does this conventional plant achieve the standards prescribed by the CPCB but also adheres to the more stringent ISO 14000 standards for effluents. Therefore as long as the operating requirements of the treatment unit are attended to meticulously, even conventional systems will deliver the required results. Studies reveal that MBR systems and CAS processes with similar configurations will deliver almost identical effluent qualities.

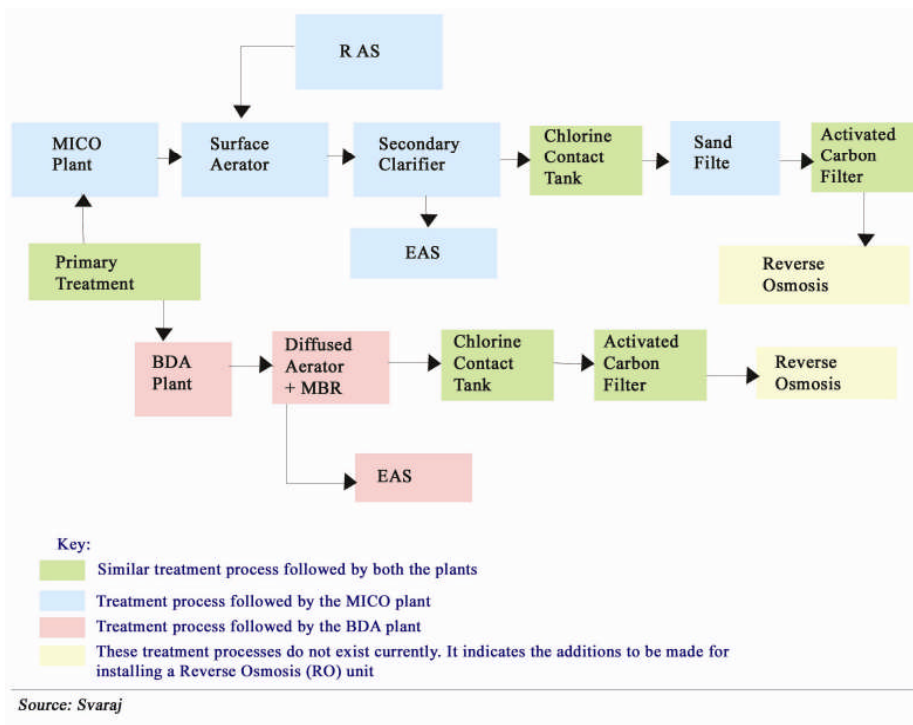
As seen in Table 4 both plants achieve the minimum standards of effluent discharge set by the CPCB for land irrigation purposes. Although the immense energy consumption for an MBR can be offset for the high quality of water produced, the question to be answered is whether there is a need for such intensive treatment. Each of these plants produces water that might be of varying quality, but they are both suitable and used for the same end purpose/applications. However when recycled water is

meant for drinking, then a MBR system might be more beneficial and cost effective. This is mainly because it produces effluents that can be fed directly to a RO unit, circumventing the need for additional tertiary treatment. For example the direct addition of an RO unit at the BDA plant will produce water that is potable but at the MICO plant this would require the installation of an additional UF or MF membrane before the RO unit is set up (See Figure 1).

Table 5: Treated Effluent Quality at the MICO & BDA

Parameters	BDA *	MICO +	CPCB Discharge Standards
BOD	1	6 - 8	100
COD	8	18 (approx.)	-
BOD/COD	0.13	0.8 -0.85	-
TSS	< 5	25 -30	200
TDS	-	950 – 1000	2100
pH	6.0 - 8.5	7.5 – 8.0	5.5 - 9
Temperature	-	27 ° C	-
Oil & Grease	-	6 - 8	10
Chloride	-	400-450	600
Turbidity	0.05 NTU	-	-

Figure 1



Every treatment process and technology adopted has a set of pros and cons. However the terms - 'pros' and 'cons', are a relative concept, which means that a positive feature for one plant might be a negative for another. The most suitable treatment method is one that optimally exploits the abundant factors and minimizes the requirement of the scarce resources of a particular treatment plant.

The Means to the End

Although planning is the first step, it can facilitate the effective treatment only when there is easy access to the required resources and an ability to manage them. Some of the other factors that are equally essential for the success of treatment are:

Availability of efficient technology that is cost effective. Does a trade off exist between 'low priced, cost effective' technology and 'efficient' technology? Imitation of technology that has been adopted successfully in the West may not always be best for local treatment plants. Cost is invariably a major obstacle in the obtaining effective treatment equipment. Cleaning an aquifer that was polluted by a sulfuric acid manufacturing unit in Rajasthan was estimated to be Rs 40 crores.

This was not economically viable.

Technical ability to manufacture, install and operate treatment systems. Is the development indigenous skill and local manufacturing of products the key to providing technology that is both cost-effective and efficient?

Social acceptance and awareness. The fact that recycled water is more expensive than fresh water is a significant incentive for polluters to avoid treatment. Therefore not only is there a need for improvement of current treatment practices but also a change in awareness levels.

The perception that end-of pipe treatment like CETPs can completely abate pollution is a grave misconception. It is that very idea that resulted in the aggravation of the problem, as there was a shift in attention away from waste minimisation and clean production technologies towards operation of treatment and disposal systems. The effective control, management and reduction of wastes can be achieved only through a comprehensive

strategy. It involves precautions and changes at every stage of the production cycle, starting from the use of the right raw materials up till the safe disposal of unwanted materials. CETPs are just one of the stepping-stones towards achieving pollution-free production.

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