Designing Zero Discharge System for a Textile Waste Water Treatment Plant

ecp consulting

infusing intelligence

S.ESWARAMOORTHI
Scientific & Technical Consultant

18th January 2010

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ACF	Activated Carbon Filter
BOD	Biological Oxygen Demand
CETP	Common Effluent Treatment Plant
COD	Chemical Oxygen Demand
FBBR	Fluidized Bed Bioreactor
HRT	Hydraulic Residence Time
MBR	Membrane Bioreactor
MLSS	Mixed Liquor Suspended Solids
OTE	Oxygen Transfer Efficiency
PSF	Pressure Sand Filter
SBR	Sequencing Batch Reactor
SRT	Solids Retention Time
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UASB	Upflow Anaerobic Sludge Blanket
VOC	Volatile Organic Compounds

DESIGNING ZERO DISCHARGE SYSTEM FOR A TEXTILE WASTE WATER TREATMENT PLANT

S.ESWARAMOORTHI[1]

ECP CONSULTING

1. INTRODUCTION

The concept of zero discharge implies that the process water utilized in dyeing and bleaching operations is recovered for reuse to an extend that no discharge of effluent into the environment is achieved. However, there may be solid wastes generated in the process and that should be stored in a secured landfill. The main objective of zero discharge treatment system is minimizing the effect of waste water on the environment as far as possible.

Any zero discharge treatment system design should consider the following facts/requirements:

1. Quantity of the effluent to be treated.
2. Variability in time of the quantity as well as quality of the effluent.
3. Unit processes suitable for achieving desired purposes [such as removal of total suspended solids (TSS), reduction in biological oxygen demand (BOD), *etc.*] for the given nature of the effluent.
4. The upper and lower limits of performance of each unit process.
5. The durability of the system to be adopted.
6. The feasibility of establishing suitable collection and conveyance system in the case of a common treatment facility.

2. COLLECTION AND CONVEYANCE

Only little attention is paid towards the design of a collection and conveyance system. However, its role is very much important for the successful operation of a zero discharge treatment facility[2]. Some of the design aspects of a collection and conveyance system suitable for textile waste water is considered here.

1. Proposed/available location for the common effluent treatment facility, extend of land available, and the possibility for further expansion are to be considered. The locality shall determine the total length of the pipeline required, its route, required slope, placement for air-lock release valves, and location of additional collection sumps (if found necessary).
2. Levelling survey should be conducted to estimate the latitude, longitude and, height above Mean Sea Level (MSL) of each member unit and that of the proposed common effluent treatment plant (CETP). This information is important to study the feasibility of achieving gravity flow for effluent transport, as well as in the design of treated water supply lines to the member units from the CETP.

1 e-mail: info@ecpconsulting.in

2 Refer *Pipeline Design for Effluent Transport in Common Effluent Treatment Plants,* available for download from www.ecpconsulting.in, for a more detailed discussion.

3. Estimation of quantity of effluent generated per day in each member unit is essential. Also, an assessment should be made about the normal and peak flow from each member unit. If any member unit is opting to expand their discharge capacity in the future, that should also be taken into account. Based on this assessment, each member unit should be allocated a maximum discharge that should never be violated for any reason.
4. Estimating the available storage capacity of effluent storage tanks at each member unit is also essential. The provision for individual storage tank at each member unit achieves several things: i) reduces the degree of peak flow; ii) allow the effluent to cool down to ambient temperature so that the pipeline is not affected ; iii) improves homogenization that reduces the occurrence of shocks in the equalization tank of the CETP which helps in maintaining the stability of the treatment system; iv) ability to store extra effluent during pipeline and CETP maintenance operations, *etc.*
5. Provision for removal of debris, grits, and suspended solids should be given at each member unit[3].
6. Temperature range of the effluent that may get into the pipeline and the capacity of the pipeline material to withstand this temperature range is to be considered.
7. The durability of the material of construction of the pipeline is very much essential. As digging for pipeline is a tedious process and that requires prior approval from various governmental agencies, the durability of the chosen pipeline should fall somewhere around 30 to 50 years. Some of the important requirements for a good and efficient pipeline are i) the ability to withstand burial pressure and operating pressure, ii) ability to withstand corrosion by the effluent, iii) ability to provide and maintain smoother inner surface over a period of time that reduces retardation to the flow and energy requirement, iv) ability to handle peak loads, v) ability to handle expanded flow as per expected future demands, vi) characteristics amenable for easy jointing and bending, *etc.*
8. As assessment about proposed/available pipeline route with a list of existing natural and man-made impediments such as roads, railway lines, rivers, water logged areas and bridge crossings, and proximity to already existing pipelines - especially that of drinking water lines – have to be made.
9. Accessibility to road, availability of electric power, provision for secured landfill[4], proximity to urban population[5] and archaeological treasures[6] should also be taken into account.
10. The collection and conveyance system should consider the implementation of gravity flow and/or pumped flow depending on the prevailing environmental conditions. Implementation

3 Removal of suspended solids before the effluent enters the pipeline is one of the best option to improve service time of the pipeline. This shall also reduce the maintenance problems, such as clogging, and manhole overflow along the pipeline.

4 The initial secured landfill may get filled over a period of time. Therefore, it may be necessary to construct additional secured landfills as per requirement. The most important aspect of a place for secured landfill is that it should lie relatively at a higher elevation so that during rainy season no flooding occurs. Further, provision should be given for transport of seepage from the secured landfill to the equalization tank. There are several requirements for a *hazard waste management facility* as defined by the Central Pollution Control Board, New Delhi, and, therefore, the selection of a place for secured land fill and its design should meet these criteria. As far as possible, secured landfills should be nearby the common effluent treatment facility so that seepage handling may be made easy. It is also essential to allocate a larger area for secured landfill to meet future demands.

5 As far as possible, the CETP location should be away from urban population to minimize or, nullify the environmental impact upon them.

6 Archaeological treasures and their proximity is one of the factor considered while giving the consent for the establishment of a CETP.

of gravity flow is one of the options that shall reduce energy demand – thereby paving way for reduced operating cost per litre of effluent to be treated.

3. PROPOSED TREATMENT SCHEMES

Once effluent reaches the CETP, it has to be stored, equalized, and made suitable for further treatment. There are several options available for treating the effluent. The effluent may be a combined one – meaning that a mixture of dye bath, wash water, printing, and bleaching effluent. It may also be segregated. We shall consider the pros and cons of each of these methods in brief here.

3.1 TREATING SEGGREGATED AND COMBINED RAW EFFLUENT

Segregation essentially means separating effluent based on their generation process – such as dyeing, bleaching, printing, *etc.* The advantages and disadvantages are discussed here in brief:

1. The main advantage here is that depending on the nature of the effluent, necessary treatment is given only to the quantity of effluent generated in that particular process. For example, if dye bath is segregated, since its volume is low compared to the wash water and its total dissolved solids (TDS) content is higher, it can be directly evaporated with an evaporator; if dye bath is combined with wash water, then it is necessary to handle the whole volume down through all required treatment processes.
2. Due to segregation, each type of effluent has to be stored in separate tanks at each member units, and each of them have to be passed through a separate pipeline to the CETP. Employment of separate pumps may also be necessary. This is, most of the time, an expensive and awkward option.
3. Depending on the nature of the segregated effluent, employment of different unit processes and equipments may be necessary. Employment of separate treatment units for each type of effluent shall result in higher capital investment that shall reduce the financial feasibility of the project. Due to increased maintenance load, this shall also increase operating costs.
4. As the temperature of the dye bath is around 70-80°C, it shall take more time for natural cooling when compared with combined raw effluent. Thus, in order to provide more time, a storage tank with larger detention time may be required. Or, forced cooling has to be implemented. This is an additional cost to the total project. If wash water is allowed to mix with the dye bath, the temperature of the combined raw effluent shall have already been lowered since the temperature of the wash water utilized for washing purpose is always at ambient.
5. In the case of segregation, there is no way of reducing the organics loading of the effluent. Therefore, the condensate from the evaporator may contain high levels of volatile organic carbon (VOC) compounds. Presence of these compounds in the recovered water shall pose problems in dyeing such as undesired tint. In the case of combined raw effluent, most of the organics in the effluent shall be exhausted by microbes during aerobic/anaerobic oxidation. Also, recalcitrant organics shall find their way into sludge by adopting suitable unit processes. Thus, the organics content of the recovered water utilizing combined raw effluent shall be comparatively lower.
6. When dye bath is directly treated with an evaporator, the problem of colour removal has to be properly addressed. Normally, chlorine is utilized for this purpose. Since chlorine forms chloro-organic compounds, which are carcinogenic even at the parts per million level, it shall have undesirable effect on the environment. Both chlorine and ozone (the other option

for colour removal) are highly corrosive. Therefore, traces of them have to be removed before the effluent reaches the evaporator. This is an additional cost. Further, chlorine/ozone production and handling is problematic and requires special skills. Accidental release of both of these gases shall pose severe health risks.

The only disadvantage with handling combined raw effluent is that a large volume has to be handled. However, considering the benefits, it is always desirable to treat combined raw effluent instead of engaging segregation.

3.2 PRIMARY TREATMENT SYSTEM

The main objectives of primary treatment system are:

1. Removal of suspended solids is an important aspect of primary treatment. Suspended solids does not need any treatment other than their total removal. Since suspended solids may or may not chemically react with the effluent, their total removal may also benefit through reduced chemical consumption – if they react with added treatment chemicals.
2. Achieving flow equalization, thereby enabling uninterrupted supply of effluent to the treatment units. It should be noted that if the purpose of equalization is only to achieve flow equalization, it is a poor design. Equalization process should also address the problem of homogenization of the influent so that variability in effluent characteristics are greatly minimized. This paves way for designing a system with clear upper and lower operating limits and assist in the maintenance of good performance[7].
3. Adjustment of pH to neutral is another important aspect of primary treatment. Normally, pH correction is made after equalization with the aid of a flash mixer and then the effluent passes to the next treatment unit. Whereas, it is always beneficial to carry out pH correction at the equalization tank itself. There are certain benefits associated with this aspect. One of them is that due to higher detention time available in the equalization tank - compared to inline acid dosing[8] for pH adjustment – the variability in pH is largely controlled. Further, enough time is given for neutralization so that all chemical reactions resulting from the addition of acid are essentially completed. Further, all carbonates in the influent – even slowly reacting one - are brought into solution by acidification at the equalization tank. Any further pH adjustment to the effluent from equalization tank should be carried out in a flash mixer.
4. Oil and grease removal is one of the important aspect in the design of a primary treatment system. Normally oil skimmer is utilized for this purpose. Also, removal of free chlorine[9] is very much essential – since presence of free chlorine in the effluent shall damage the reverse osmosis membranes.
5. After pH adjustment, the effluent should be treated by any one of the following desired processes to achieve reduction in biological oxygen demand (BOD) and chemical oxygen demand (COD). Some of the available options are: i) simple aeration; ii) activated sludge

7 Equalization is an important process that decides the performance of the system down the line. Often, design of proper equalization system is improper due to the understanding that it needs only to equalize the flow. But the fact remains that a good equalization process should also address the problem of homogenization and maintaining, as far as possible, a constant loading rate of desired effluent constituents. Some of the best practices in the design of equalization process are considered in the article *Achieving Zero Discharge in Industrial Waste Water Treatment Plants* which is available for download from www.ecpconsulting.in

8 Textile waste water pH is always in alkaline range. Hence, neutralization is done using acid.

9 The combined raw effluent may contain higher levels of *free chlorine* if it has bleaching effluent as one of its components. However, by utilizing peroxide bleaching, it is possible to generate effluent free from *free chlorine*. All member units have to make an agreement with regard to the bleaching process to be employed.

process with/without aeration (this includes SBR and UASB processes); iii) aerobic/ anaerobic digestion with fludized bed bioreactor (FBBR); iv) use of a membrane bioreactor (MBR). Selection of any one of these processes for primary treatment of effluent for the reduction of BOD/COD largely depends on the available financial and other resources (such as land) and desired level of performance. These are described briefly in the following paragraphs.

(a) During simple aeration, supply of air is continuously maintained and that supplies required quantity of oxygen for the growth of microbial population. The organics in the effluent are consumed by aerobic bacteria and results in BOD/COD reduction. Under this process, the solids retention time (SRT) is equal to hydraulic retention time (HRT). Provision of enough detention time is essential for running a simple aeration system; otherwise, BOD/COD reduction shall be less.

(b) Under activated sludge process, aeration stage is followed by a settler where the separation of suspended solids is achieved. The settled solids contain active microbes that are returned to the aeration tank. By recirculating the suspended solids, the solids retention time (SRT) is enhanced, thereby promoting the degradation of organics. The activated sludge process may either be an aerobic process, an anoxic process or, a hybrid process where aerobic and anoxic conditions are cycled[10]. The selection of aerobic or, anaerobic process largely depends on the nature of the effluent. The main advantage of employing activated sludge process is that it requires comparatively less aeration tank volume, less detention time, and operates under high mixed liquor suspended solids (MLSS) concentration compared to simple aeration. Adoption of this method enables reduction of shock loads. Upflow Anaerobic Sludge Blanket (UASB) reactor employs anaerobic digestion under activated sludge process while, Sequential Batch Rector (SBR) utilizes both aerobic and anoxic processes[11]. Using USAB it is possible to generate biogas from the waste water and generate electricity[12]. The SBR process is very much useful in achieving nitrate removal[13].

(c) While simple aeration and activated sludge processes discussed above employs suspended growth kinetics, employment of FBBR utilizes attached growth kinetics. The main advantage of employing FBBR are many. Some of them are:

   i) higher retention of suspended biomass,

   ii) prolonged solids retention time (SRT) to enable complete microbial degradation of slowly degrading organics,

   iii) reduction in shock loads, and

   iv) high quality effluent low in BOD/COD.

(d) Use of MBR for textile waste water treatment is one of the best available options. It reduces the foot print, improves BOD/COD reduction, eliminates the need for a secondary clarifier, removes suspended solids, gives uniform output of effluent, can be

---

10 The desired duration of the cycle depends on the intensity of nitrification and denitrification.

11 In SBR, aeration is switched on during *fill* and *react* periods. During *fill* period waste water is pumped into SBR; *react* period is the time in which microbial reaction with waste water constituents is allowed to happen. This is followed by a *quiescent* period when suspended solids are allowed to settle. Then, the supernatant is decanted and settled sludge that contains microbes is recycled in the same SBR tank. During aeration, NH_4-N is oxidized to NO_3.

12 Use of UASB process also reduces the quantity of sludge generated. However, SRT should be maintained high enough to achieve desired results.

13 For denitrification to be effective, the switch-off period should be prolonged to maintain anoxic water column for a sufficient period.

operated at higher MLSS concentration, and reduces shocks[14]. However, the capital investment associated with the establishment of a MBR system is higher than other systems.

6. The next step in primary treatment is colour and turbidity removal. It should be remembered here that colour removal should be effected only after BOD/COD reduction. Otherwise, the load on the unit process that removes the colour shall be heavy and it may not be possible to achieve desired output. For colour removal the following unit processes can be adopted: i) chlorination, ii) ozonation, iii) employment of activated carbon filter.
   (a) Of these three methods, chlorination is not considered environment friendly and its application in waste water treatment is widely disputed.
   (b) Ozonation may be carried out alone or, it may be combined with UV irradiation. UV-Ozonation is a highly efficient process when compared with simple ozonation. Since ozone is a highly oxidizing agent, colour removal is easily achieved. Some other desired output obtained due to the application of ozone is that it oxidizes dissolved iron in the waste water to colloidal iron hydroxide. Due to this the waste water turns turbid. Since iron hydroxide adsorbs most of the trace metals in the waste water, by proper filtration (for example, using a pressure sand filter), both dissolved iron and other trace elements are removed. Removal of dissolved iron is most critical since it is toxic to the reverse osmosis membranes used in secondary treatment for water recovery.
   (c) When the required level of colour removal is less, employment of activated carbon filter can also be considered. Activated carbon filter removes traces of free chlorine, organics, and many trace elements present in the waste water. Due to its granular form, it also removes a part of suspended solids. The main problem with the employment of activated carbon filter is that it has to be renewed often.
   (d) Turbidity removal is also achieved by employing PSF and ACF.

3.3 SECONDARY TREATMENT SYSTEM

Once suspended solids are removed, BOD/COD reduction is achieved, turbidity and colour are removed, the water has to be subjected to secondary treatment for the recovery of water. There are several aspects that should be considered in the design of a secondary treatment system.

1. The secondary treatment system, that normally employs reverse osmosis membranes, should be able to operate with the desired TDS level typical of the effluent. It should also generate permeate with acceptable quality.
2. It should be able to withstand membrane scaling caused by various constituents in the effluent. Biofouling is another problem that has to be suitably controlled.
3. To achieve maximum benefits, the percentage of recovery of pure water shall be maintained at higher side. However, increased recovery also require higher operating pressure and also results in frequent fouling of the membrane. Therefore, it is essential to utilize highly optimized system in place.
4. By monitoring the reverse osmosis feed quality with suitable sensors, automated backwash and diversion of effluent with undesirable quality[15] to a separate tank can be achieved. These

14 Reduction in shocks is essentially due to recirculation of effluent from the membrane compartment to that of anoxic zone and maintenance of higher levels of MLSS (about 10,000 to 20,000 mg/L). A more detailed discussion about application of membrane bioreactor for textile waste water treatment is available in the article *Textile Wastewater Treatment with Membrane Bioreactor* available for download from www.ecpconsulting.in

measures are essential for the protection of the membrane system which shall increase its life time.

5. There shall always be performance degradation of the membrane system that reduces the quantity of permeate that can be obtained. Further, with time, the salt passage through the membrane increases, resulting in higher TDS permeate. In addition to these issues, backwash operations reduces total functional time of the membrane system. As the backwash frequency depends mainly on the fouling potential of the effluent and the operating conditions of the reverse osmosis system, the downtime (*i.e.*, off-line period) of the membrane system may vary from time to time. Therefore, it is essential to design the membrane system with a significant margin.
6. In order to reduce membrane fouling and backwash frequency, fouling resistant membranes may be utilized.
7. The reverse osmosis system has to implement *stages*[16] and/or *passes*[17] to obtain higher percentage of recovery and permeate of desired quality. Mixing desired quantity of permeate with the feed and recirculating it through the membrane system is another option to maintain system performance. All these things shall be considered during design phase of the membrane system.

3.4 TERTIRARY TREATMENT SYTEM

The prime objective of a tertiary treatment system is to treat the reject generated by the reverse osmosis system. Normally the tertiary system employs an evaporator that utilizes steam as heating source, produces reusable water in the form of condensate, and generates blow down and salt as by products.

1. The main problem faced in an evaporator is scaling. For good maintenance, an evaporator has to be cleaned daily.
2. When sodium sulphate is utilized in dyeing process, the salt is recovered in the evaporator – and that remains reusable. However, if sodium chloride is utilized in the dyeing process, then the recovered salt contains higher level of impurities – making it unsuitable for reuse. However, it is still possible to purify the salt and make it reusable. The ways of achieving this should be explored. If this is not achievable then, the design of secured landfill should take into account disposal of the salt recovered from the evaporator.
3. The evaporator design should consider utilization of waste heat from the steam. Co-generation is another option that has to be considered from right in the beginning.
4. The blow down from evaporator has to be treated with a solar evaporation pond. In order to enhance evaporation rate, implementation of forced evaporation methods, such a construction of a spray pond, may be considered.

---

15 For example, by monitoring the oxidation-reduction potential (ORP), presence of highly oxidising substances in the effluent, such as free chlorine, can be monitored. Automated bye passing of this effluent to another tank reduces the chances of membrane damage. Similarly, sensors may be fixed for the measurement of TDS and pH of reverse osmosis feed; the system may be automated to handle these issues in a desirable way.

16 If the reject from a membrane module is treated by another module, then this configuration is called stage. Normally, dual stage membrane systems are employed in textile waste water treatment.

17 If permeate from a membrane module is treated by another module, then this configuration is known as pass. This is mainly utilized to reduce the TDS of the permeate.

4 OPTIMIZATION OF SYSTEM DESIGN AND PERFORMANCE

The success or failure of a waste water treatment facility in achieving zero discharge largely depends on how much optimization is achieved in the design phase of the full-scale plant. When a waste water treatment system is established, it is normally thought that the system has to perform to the desired level since it is designed so. However, a lot of things are left in the design phase. Some of them are discussed below.

1. Steps for optimization should start right from pilot plant tests. The kinetic parameters obtained from pilot plant for the chosen treatment system should be employed for full-scale plant design. Allowance should be given in sizing the units by taking into consideration the variability of effluent parameters, and the expected variability in the performance of each treatment unit. The system design should also consider normal off-line period of relevant treatment unit[18], and interruptions due to maintenance should be considered. A system design that does not consider variability in effluent characteristics shall pose operational problems at later stages, finally resulting in failure to achieve desired results.
2. The performance of each treatment unit may vary from time to time depending on feed quality. For example, the substrate utilization rate in the aeration system increases exponentially with substrate concentration. If the system is properly designed, any increase in feed substrate concentration shall be smoothed out by increased substrate utilization rate – thereby reducing occurrence of shocks in the treated effluent. This shall improve performance of the treatment system and reduce system up-sets.
3. The system performance may also decline with time due to continued operation and ageing. While cleaning of the treatment unit tries to restore the performance of a treatment unit, it may not be 100% effective. Thus, proper allowance should be given in sizing each treatment unit by considering the expected life-time of the treatment unit and its average performance decline over the period in service.
4. Since aeration is an energy intensive process and consumes around 20-30% of total electric power required in a waste water treatment plant, by optimizing the aeration system it is possible to reduce operating costs. Conducting oxygen transfer efficiency (OTE) tests is an essential part of optimizing the aeration system. The actual oxygen requirement may vary from time to time and the aeration system should be able to adjust itself to prevailing conditions.
5. Due to complex nature of the substrates, the oxygen uptake rate follows a step-like curve. This can be observed by laboratory experiments. The system design should consider this fact from right in the beginning and the hydraulic residence time (HRT) of the effluent at the aeration tank should be greater than the time required for attaining a minimum oxygen uptake rate.
6. The system design should consider the effect of temperature on microbial growth and its kinetics. Since microbial growth rate decreases with temperature, the system design should be able to absorb this.

18 Pressure Sand Filter (PSF) and Activated Carbon Filter (ACF) shall be in off-line mode when backwash operation is carried out. Similarly, reverse osmosis system shall be in off-line mode during periods when feed quality exceeds the desired limits as well as during the periods of backwash. Evaporator shall be off-line when cleaning operation is conducted. The whole system shall be in off-line mode when system up-sets are observed. Proper allowance should be given in treatment capacity, hours of treatment

7. Occurrence of *short-circuiting*[19] in each tanks should be studied before commissioning the full-scale plant. Necessary remedial measures should be implemented.
8. Settling is one of the important processes employed in any waste water treatment facility[20]. The performance of settling tank largely depends on *overflow rate*[21] and the nature of the effluent. The settleability of sludge[22] shall also affect the solids retention by the settling tank. The overflow rate not only determines the percentage of removal of suspended solids – but also BOD/COD reduction associated with particulate removal. In a properly designed system, at any point in time the total suspended solids (TSS) removal should fall within desired limits. Accordingly, the BOD/COD removal efficiency should also be studied.
9. The system should always be designed to treat all the effluent generated in a day within 18 hours, keeping the remaining 6 hours to account for performance degradation, carrying out regular maintenance works, meeting unexpected interruptions, *etc.* This aspect is essential in any zero discharge treatment facility.
10. The system should always be run below the rated full capacity to ensure that the system is not throttled at any moment. This shall ensure maintenance of good performance of all treatment units over their life period.

5 RESOURCES NEEDED/REQUIREMENTS

The following technical requirements have to be met in order to establish a zero discharge system.

1. Assessment of existing treatment technologies for textile waste water treatment is a first technical requirement. Based on available information, a treatment system has to be chosen.
2. The chosen treatment system i) should be able to produce effluent with desired quality, and ii) it should not produce any harmful substances on its own.
3. In order to assess the viability of applying the selected treatment system, it is necessary and essential to conduct pilot plant test runs. It should be noted here that any zero discharge implementation with out a solid back up from pilot plant test run data is subjected to failure. The pilot plant not only provides the means of assessing the viability of technology – it also provides enough data for the design of a full-scale system. Further, any problems that may arise in a full-scale implementation can be identified.
4. The full-scale design should only be based on the combined effluent characteristics of all member units. Taking into consideration the variability in each parameter is very much essential. The treatment system design should be able to withstand at the least 99% of statistically significant variability in effluent parameters. Otherwise, the performance of the

19 *Short-circuiting* is a phenomenon where the influent escapes proper treatment by exiting the treatment unit before the desired detention time. The occurrence of this phenomenon is largely due to geometry of the tank, flow regime, placement of inlet and outlet, *etc.* A design that does not consider occurrence of *short-circuiting* is subjected to failure.

20 In waste water treatment systems employing membrane bioreactor (MBR), settling is not necessary as solids separation from liquid is accomplished by the membranes. Therefore, problems associated with sludge settleability is also overcome using a MBR.

21 This is defined as the ratio of total volume of the tank/surface area of overflow.

22 This, in turn, is affected by food/microorganisms (F/M) ratio that is maintained in the aeration tank. Operating the plant with low F/M ratio ensures good settleability of the sludge and better BOD/COD removal. Lowering this ratio requires maintenance of high MLSS concentration, which is possible only with the adoption of activated sludge process or, a membrane bioreactor (MBR) system.

treatment system shall be greatly affected[23]. It is also desirable to have some margin in the design limits to account for future performance degradation.

5. Pipeline design for effluent transport and return of treated effluent to the member units from the CETP is one of the important aspect of implementing a zero discharge system. This has already been discussed under Section-2.
6. The processes that generate the effluent are to be identified at first. Listing out all chemicals and their quantities utilized in textile wet processing is also important. This gives necessary information about the characteristics of the effluent that is generated in textile wet processing. Only then it may be possible to know the list of physical and chemical characteristics that need to be analysed in the effluent. This helps in selecting suitable treatment units.
7. Listing all energy conserving measures are very much essential to reduce operating costs. Some of these measures include employment of energy recovery device in the reverse osmosis system, waste heat recovery systems, employment of energy efficient motors and pumps, lighting, *etc.*
8. Conducting levelling survey is very much essential to design the pipeline – both for implementing gravity flow as well as for pumped flow. Collection of information about total number of member units, each one's locality, present and future discharge capacity, the number and size of available storage tanks for temporary storage of effluent at each member unit, and any other related information is very much essential for the design of a good collection and conveyance system. A poorly designed collection and conveyance system shall always bring havoc to the CETP as well as to the member units. The design should also include particulars about the placement of air-lock/pressure release valves, manholes, collection sumps, and flow meters[24]
9. The system should consider ways of handling undesirable situations such as i) feed with undesirable quality, ii) power failure, iii) periods of maintenance, and iv) flooding.

6 UNIT PROCESSES

The applicability and use of various technologies for textile waste water treatment is already described. Of all these methods, using MBR process for primary treatment is the best option. However, it is comparably costlier than other methods. Other recommended methods are SBR and UASB processes. Irrespective of the technology to be adopted, following unit processes are necessary for the treatment of the textile waste water to achieve zero discharge.

1. Removal of grits and suspended solids
2. Removal of oil & grease
3. Equalization
4. Adjustment of pH
5. Reduction of BOD/COD[25]
6. Removal of colour

---

23 Refer *Performance Optimization of Waste Water Treatment Plants* for a detailed discussion on improving performance of waste water treatment plants. This document is available for download from www.ecpconsulting.in

24 It is very much essential to have Automated Meter Reading (AMR) implementation so that any leakage or break-up along the pipeline can be immediately detected and necessary preventive measures can be taken in time. It also helps in accounting effluent flow and returned water supply from and to the CETP. Further to this, continuously monitoring the pressure inside the pipeline is very much essential in preventive maintenance.

7. Recovery of reusable water
8. Treatment of reject (from reverse osmosis system/blow out from evaporator)
9. Solid waste disposal and management.

~~~~~ ***** ~~~~~

25 This can be achieved in several ways: i) simple aeration, ii) activated sludge process with aeration tank and settling tank with a return line for supplying active sludge, iii) employment of UASB reactor, FBBR, SBR or, MBR, *etc*. The main advantage of employing UASB reactor is that it can be used to generate biogas that may be used for power generation.
~~~~~