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# Analysis of Treatment Units in Common Effluent Treatment Plant (CETP) & Advances in Treatment Processes: A Review

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***Abstract*:** Common Effluent Treatment Plant (CETP) is designed for the effective treatment of effluent released from industrial clusters, to assist the goal of small and medium-scale industries that lack the resources and technological capabilities to treat their effluent separately either due to space constraints or shortage of skilled manpower. The current study examines the different processing phases of a typical CETP and its treatment units. The current scenario of CETP in India is also mentioned in this review. Discharge standards of physico- chemical parameters specified by CPCB from the outlet of the plant were also incorporated. Additionally, several innovative treatment techniques were emphasized like ASP, Modified ASP, UASB, SBR, MBBR, BIOFOR, AOPs. Furthermore, the shortcomings and research gaps of previous studies are investigated, as are the potential for future research requirements.

***Keywords*: CETP, Effluent, ASP (Activated Sludge Process), SBR, UASB, AOP.**

## INTRODUCTION

Considering total global water as of 100% out of which 96.5% is in oceans 0.9% in the form of saline water rest 2.5% is considered as fresh water, now this fresh water is also sub divided, that is 68.7% fresh water is in the form of glaciers and ice caps and 30.1% fresh water stored in ground water and the remaining 1.2% is the fresh water which we get on Surface.

According to WHO globally, billions of people lack access to safe water and adequate sanitation. In India, less than half of the population has access to clean drinking water. About 40 percent of the world's population lacks basic sanitation, and sanitation coverage is commonly much lower in rural areas than in urban areas. Even though it appears to be in plentiful supply on the earth's surface, water is a rare and precious commodity, and only an infinitesimal part of the earth's water reserves (approximately 0.03%) constitutes the water resource which is available for human activities. Thus far, Organic Wastes and Waste Waters have been treated mostly due to pollution control, while in the future; they may act as valuable resources. Water is the basic need of all life, human, well-being and also for economic development. Because of increasing industrialization, urbanization and other anthropogenic activities, and the water quality is getting degraded day by day [1].

In India's biggest cities, an estimated 38354 million litres per day (MLD) of sewage is created, while the sewage treatment capacity is only 11786 MLD. Similarly, just 60% of industrial waste water, primarily from large-scale companies, gets treated. State-owned sewage treatment plants, which handle municipal waste water, and common effluent treatment plants, which treat wastewater from small-scale companies, are also not meeting specified criteria. As a result, effluent from treatment facilities is frequently unfit for residential use, and waste water reuse is generally limited to agricultural and industrial reasons [2].

The quantity of gray/wastewater is rising in proportion to the fast development of cities and home water supplies. According to CPHEEO estimates, around 70-80 percent of the water provided for household consumption is created as wastewater [2].
Thus, an overall review of water resources reveals that in the next years, there will be a double-edged challenge to cope with owing to rising population and industrialization: lower fresh water supply and increased wastewater creation [2].
Generally, wastewater further subdivided into 2 types that are Municipal wastewater and Industrial wastewater.

**Municipal wastewater** originates from domestic household activities, it can also include water that is discharged from commercial and business buildings and institutions, along with ground water. Water that collects from a storm can also be present in domestic wastewater. The pollution of household wastewater is mainly due to the flushing of toilets, kitchen and cleaning water polluted with bacteria, viruses, washing and cleaning agents including dirt and rests of food. It is comparatively easy to almost completely break down these pollutants with the help of micro-organisms used in wastewater treatment plants. This type of water can be treated easily due to its characteristics [3].

**Industrial wastewater** or “Industrial Waste” means any Waste or substance spilled, Discharged, flowing, or allowed to escape from any producing, manufacturing, processing, chemical, Waste or materials storage area, institutional, governmental, or agricultural operation or from any other operation, or from the development, recovery or processing of any material resource. It is more difficult to treat influent due to the examination that must take place at an industry-based level. Industrial sources of wastewater contain contaminants such as; oil, pharmaceuticals, pesticides, silt, chemicals, other by-products, etc; which needs heavy treatment before discharging into water body [4].

## WHY WASTEWATER IS NECESSARY TO TREAT

Wastewater treatment is very important for domestic sewage and industrial effluents before discharging it into any river or stream. Untreated wastewater creates lots of problems when get mixed with natural streams. Hence it must be treated to an extent so as to reduce its adverse effects on environment and to bring its pollution load within assimilative capacity of environment [5].

In general, the industry may be damaging and exploiting resources such as water. Its excessive use of water and development of waste, especially wastewater, can have a long-term impact on the environment. These two components of water consumption and waste creation contribute to a variety of environmental problems, including air and groundwater contamination. Furthermore, in most situations, industrial activity reduces the quantity of minerals in groundwater while increasing $CO_2$ levels in our atmosphere. To make matters worse, the chemical changes induced by industrial effluent have a negative impact on marine life and agriculture productivity.

As a result, it would not be incorrect to claim that industrial wastewater treatment is no longer a choice, but rather a need [6]. Industrial wastewater is also very much disastrous for natural streams if not treated prior to its disposal. Although its volume may be less but due to excessive concentration of pollutants it can degrade the quality of natural water considerably [5].

1. The **River Yamuna’s** 22-km stretch in Delhi is barely 2% of the length of the river, but contributes over 70% of the pollution load.
2. Around 1.3 billion liters of raw sewage and 250 million liters of industrial effluent are added to the **Ganges River** daily.

Table 1 IllEffects of Industrial Wastewaters [29]

| S. No. | Parameter | Ill Effects |
|---|---|---|
| 1 | Acid | Damages metal/concrete structures, pumps etc. |
| | | Produce hydrogen sulfide gas |
| | | Destroy microorganism |
| 2 | Alkalies | Break natural buffer systems |
| | | Destroy microorganism |
| | | Produce asphyxiation by coagulation of gill secretion in fish |
| 3 | Suspended Matter | Reduce photosynthetic activity |
| | | Chock gills of fish |
| | | Interfere fish breeding |
| | | Formation of floating mass of evil odour |
| 4 | Toxic Metals | Cause chromosome damage and interfere heredity |
| | | Arrest movements of gill filaments |

| | | |
|---|---|---|
| | | Destroy microorganism |
| 5 | Pesticides | Changes metabolic activity of body |
| | | Depresses photoplankton in plankton |
| 6 | Dyes | Imparts colour even when present in micro- quantities. |
| 7 | Oils | Affects reaeration of water |
| | | Coats gills of fish |
| | | Spoils beaches |

Discharge standards of some of the most important parameters which drastically affect the Industrial effluent are shown in table 2.

Table 2 Discharge standards specified by Government of India in 2016.

| **S.No.** | **Parameters** | **Standards** | | | |
|---|---|---|---|---|---|
| | | **Inland Surface water** | **Public Sewers** | **Land for Irrigation** | **Marine coastal areas** |
| 1 | pH | 5.5 - 9 | 5.5 - 9 | 5.5 - 9 | 5.5 - 9 |
| 2 | TDS | 2100 | --- | 2100 | --- |
| 3 | TSS | 100 | 600 | 200 | 100 |
| 4 | BOD (3 days @27°C) | 30 | 350 | 100 | 100 |
| 5 | COD | 250 | --- | --- | 250 |
| 6 | O&G | 10 | --- | 10 | 20 |
| 7 | Chloride | 1000 | --- | 600 | --- |
| 8 | Sulphate | 1000 | --- | 1000 | --- |
| 9 | Ammonical Nitrogen as N | 50 | 50 | 50 | 50 |
| 10 | Total Kjeldahl Nitrogen as $NH_3$ | 100 | --- | --- | 100 |
| 11 | Arsenic | 0.2 | 0.2 | 0.2 | 0.2 |
| 12 | Mercury | 0.01 | 0.01 | 0.01 | 0.01 |
| 13 | Lead | 0.1 | 1 | 0.1 | 2 |
| 14 | Cadmium | 0.05 | 1 | --- | 2 |
| 15 | Copper | 3 | 3 | --- | 3 |
| 16 | Zinc | 5 | 15 | --- | 15 |
| 17 | Nickel | 3 | 5 | --- | 5 |
| 18 | Fluoride | 2 | 15 | --- | 15 |
| 19 | Iron | 3 | 3 | --- | 3 |
| 20 | Manganese | 2 | 2 | --- | 2 |
| 21 | Pesticides | Abs | Abs | Abs | Abs |
| 22 | Phenolic compounds as ($C_6H_5OH$) | 1.0 | --- | --- | 5.0 |

*Note- All values are measured in mg/l except pH.

## METHODS TO TREAT WASTEWATER

Water pollution may occur from a variety of sources, including residences, industry, mining, and infiltration, but one of the most significant is the widespread use of water by industry [7], [8], [9]. Water is often classified into four types:
(1) Runoff from impermeable surfaces,
(2) Home wastewater,
(3) Agricultural water, and
(4) Industrial wastewaters [9], [10].

Their toxicity, however, is determined by their composition, which is regulated by their industrial origin. In general, the challenges faced during wastewater treatment are quite complicated since the effluent comprises a variety of contaminants depending on its source. As a result, there are several types of effluents to treat, each with unique properties that necessitate particular treatment techniques [9].

**CLASSIFICATION OF TREATMENT**
on the basis of

- Level of Treatment
  - Preliminary
  - Primary
  - Secondary
  - Tertiary
- Method of Treatment
  - Physical
  - Chemical
  - Biological
- Condition of Treatment
  - Aerobic
  - Anaerobic

## COMMON EFFLUENT TREATMENT PLANT (CETP)

Small Scale Industries (SSI) generally found it difficult to establish and operate individual effluent treatment plant due to their limited size and scale of operations (CPCB 2016).The Ministry of Environment and Forest of the Government of India has created a government supported plan called "Common Effluent Treatment Plant" in order to create a cooperative movement of pollution management, specifically to treat effluent from industrial clusters. The concept of a Common Effluent Treatment Plant is the treatment of effluents by a collaborative effort, primarily for a cluster of small and medium size industrial units. This approach is analogous to the Municipal Corporation's treatment of sewage from all individual dwelling [11].

## OBJECTIVES OF CETP

The primary goal of CETP is to lower individual unit treatment costs while safeguarding the environment.
1. Achieve "Economics of scale" in waste treatment, lowering the cost of pollution abatement for individual factories.
2. To reduce the issue of a shortage of technical help and skilled workers, as fewer plants need fewer people.
3. To address the issue of shortage of space, because the centralized facility may be planned ahead of time to guarantee appropriate space is available.
4. To alleviate monitoring issues for pollution control boards.
5. Organize the disposal of treated wastes and sludge, as well as increase recycling and reuse options [11].
6. Monitoring of the effluent becomes easy for the overall Industrial area.

**1. Homogenous**: In such industrial regions, industries manufacture similar products or effluent of nearly the same composition. For example, paper, tanneries, etc.

**2. Heterogeneous**: Industries that produce wildly disparate commodities when grouped and the unequal composition of effluent observed in the plant are generally termed as heterogeneous CETP. For example, soft drinks, pharmaceuticals, chemical, canneries, and so on [11].

Table 3 State/UT-wise list of Common Effluent Treatment Plants as per (CPCB 2016)

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

Central Pollution Control Board carried out study during 2015-16 for assessment of actual need for common effluent treatment plants in the country and to know the industrial clusters to be serviced by these CETPs. The study has revealed that 193 Common Effluent Treatment Plants (CETPs) have been installed in the country, which serve 212 industrial areas/estates (CPCB 2016). State wise characterization of common effluent treatment has been demonstrated in table 3.

## DESIGN OF A CETP/ TREATMENT UNITS OF CETP

All industrial wastewater treatment facilities, including the CETP, are normally made up of a combination of independent unit processes, each of which aids in the performance of the other unit processes with the wastewater passing through the plant. As a result of the sequential organization of the unit processes, a treatment train is produced, and specific quality of wastewater is expected at the conclusion of the treatment train. The quantity of treatment required as well as the expected quality of treated wastewater, are determined by the wastewater parameters at the intake and the complicated design of the plant [12], [13]. The pre-treatment and primary treatment units are primarily size-based separation units necessary for basic industrial effluent cleaning. Because the effluent generated by primary treatment units is unfit for release, secondary and tertiary treatment processes are used. Depending on the effluent composition and the procedures used, primary treatment units can remove COD and TDS/TSS in the range of 10–40%. Secondary treatment processes can lower COD, BOD, and TSS levels in industrial effluent by up to 85–95 percent. Tertiary treatment facilities are often needed for the ultimate polishing of effluent by removing toxic and hazardous pollutants to the appropriate levels.It has been stated that the use of tertiary treatment units may successfully remove up to 99 percent of contaminants [13], [14].

We will now go over the various treatment units that are commonly used in CETP in order to offer a fundamental grasp of the efficacy of CETP.

## 1. TREATMENT UNITS IN CETP

**1.1 Preliminary treatment units: -**Preliminary treatment is required to remove the coarse solids and other large materials from raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units. A number of unit operations are engaged in the preliminary treatment of wastewater to eliminate undesirable characteristics of wastewater. Sometimes member industries do preliminary treatment in their premises, before sending the effluent to CETP for further treatment. If preliminary treatment or pre-treatment is taken up by individual member industry, it improves the performance of CETP.

Table 4 Preliminary treatment units with description

| S.No | Preliminary treatment units | Description |
|---|---|---|
| 1 | Bar screen (Coarse & Fine) | Screens are motorized mechanical or manual type for removal of floating waste material coming with influent. The Efficiency of screens is approximately 80%. |
| 2 | Raw effluent sump | Wastewater is generally stored in this tank, for measurement of water level of RES Sump water level sensors are provided, we can see the level of sump displayed on PLC SCADA system. |
| 3 | Grit removal chamber | In this chamber with the help of pneumatic uplift screw grit is been removed and collected in the collection tank. |

| | | |
|---|---|---|
| 4 | Oil & Skimming tank | For removal of oil & grease from effluent a motorized movable trolley is installed on the oil skimmer tank, the movable trolley is known as travelling bridge. Travelling bridge works like a train. One rubber scrapper provided in the lower side of the travelling bridge that removed oil & grease from effluent and drops it in the launder and further collected in a tank provided. The travelling bridge travel both backward and forward direction, the limit is provided for its backward and forward direction. |
| 5 | Equalization tank | The circular shape equalization tank is installed after oil and skimming tank, the equalization tank properly mix the incoming influent from oil skimmer tank. Air blowers are also provided for aeration of influent in the equalization tank. Equalization tank is generally used to make the effluent homogenous; pH correction is also been done. |
| 6 | Pre- aeration | If the influent contains some toxic gases and imparts colour also, then pre-aeration is provided before the biological treatment, so that some foul gases released and intermixing of oxygen is been done, which will further help aerobic treatment also. |

**1.2 Primary treatment units:** -Primary treatment of wastewater is the first step in the wastewater treatment process or it may be the second step after the preliminary treatment. It involves physical separation of suspended solids. This process is helpful in reduction of total suspended solids (TSS) and associated biochemical oxygen demand (BOD) levels and prepares the waste for the next step in the wastewater treatment process. The objective of primary treatment is to remove settleable organic and inorganic solids by sedimentation and removal of materials that float (scum) by skimming. 65% of the oil and grease are removed during primary treatment.

Table 5 Primary treatment units with description

| S.No | Primary treatment units | Description |
|---|---|---|
| 1 | Flash mixing tank | The influent from the preliminary treatment unit flows to the flash mixer where flocculation takes place. A chemical flocculent, polyelectrolyte solution or any other coagulant is dosed through dosing pumps to enhance the flocculation process by bringing together the particles to form large flocs which settle out more quickly. Agitators are installed in the chambers, where it mixes Polyelectrolyte, Lime, and Alum. Flash mixer works like as mechanical stirrer, optimum dosage is designed for lime, poly and alum to assure the purpose of developing flocks [15]. |
| 2 | Primary clarifier | The effluent leaving the Flash mixer is fed from bottom into the Clariflocculator under gravity. A bottom scrapper mechanism is provided with rubber squeegees to push the settled sludge to the sludge hopper in the Clariflocculator bottom canter. In the primary clarification process solids are removed by the physical treatment process before biological treatment of effluent. Primary clarifier is very cost-effective path for removal of solids after de-gritting and basic screening process. Scum is been removed by surface skimmer installed in clarifier, settled sludge is removed by an underground sludge removal scrapper system, and gets collected in primary collection sump. Primary clarifier removes 80% to 95% settled solid and 45% to 65% TSS and total BOD removed 25% to 55%. |

**1.3 Secondary treatment units: -** This process involves decomposition of suspended and dissolved organic matter in waste water using microbes. The mainly used biological treatment processes are activated sludge process or the biological filtration methods. Biological treatment processes mainly used for secondary treatment and are based on microbial action to decompose suspended and dissolved organic wastewater. Microbes use the organic compounds as both a source of carbon and as a source of energy. Biological treatment can be either aerobic where microbes require oxygen to grow or anaerobic where microbes grow in absence of oxygen or facultative where microbes can grow with or without oxygen. Micro-organisms may be either attached to surface as in trickling filter or be unattached in a liquid suspension as in activated sludge process.

Table 6 Secondary treatment units with description

| S.No | Secondary treatment units | Description |
|---|---|---|
| 1 | Activated sludge process (ASP) | The infrastructure of a basic ASP (Fig. 1) consists of a single bioreactor operated continuously where suspended microorganisms consume the colloidal and dissolved organic matter. The reactor is aerated to provide dissolved oxygen (DO) for aerobic biodegradation. Bacteria consume one part of the colloidal and dissolved carbonaceous compounds to satisfy their energetic needs (catabolism), and synthesize another part – along with a small proportion of ammonium and phosphorus – into new cellular tissues (anabolism). A settling tank (referred to as secondary settler or clarifier) where activated sludge (flocculated biomass) is gravitationally separated from the treated wastewater. Sludge recycles line returning the major proportion of the settled sludge to the bioreactor, thus allowing maintaining a high bacterial concentration in the reactor so as to intensify the biological nutrient removal. A sludge wastage line at the bottom of the clarifier, from where a small fraction of sludge is withdrawn in order to stabilize the biomass concentration in the bioreactor and to fix an adequate SRT, the excess sludge withdrawn is then treated separately [16]. |
| 2 | Secondary clarifier | The overflow from the aeration tanks with active biological solids is admitted into secondary clarifiers. The settled sludge in the clarifier is pumped back to the aeration tank to maintain the bacteriological population. Secondary clarifier is a circular shape unit installed after the aeration tank where activated sludge settle down in the bottom and the dead one floats and further removed out in the secondary sludge sump. The treated water passes through the outer channel of the secondary clarifier. An underground pipe connected between secondary clarifier and activated sludge sump where return activated sludge pump is installed for recirculation of activated sludge in the aeration tank [17]. |
| 3 | Trickling filter | A trickling filter is a three-phase system with fixed biofilm carriers. Wastewater enters the bioreactor through a distribution system, trickles downward over the biofilm surface, and air moves upward or downward in the third phase. Trickling filter components typically include a distribution system, containment structure, rock or plastic media, under drain, and ventilation system. Wastewater treatment using the trickling filter results in a net production of total suspended solids. Therefore, liquid-solids separation is required, and is typically achieved with circular or rectangular secondary clarifiers. The trickling filter process typically includes an influent pump station, trickling filter, trickling filter recirculation pump station, and liquid-solids separation unit [18]. |
| 4 | Oxidation pond | Oxidation Ponds also known as stabilization ponds or lagoons. They are large open flow through earthen basins in which heterotrophic bacteria degrade organic matter in the sewage to produce cellular material and minerals. Constructed wetlands (CWs) have been widely applied to the treatment of various wastewaters in many countries and regions because of the advantages of low operational cost, versatile pollutant removal performance, limited and low skill labour requirements and good landscape integration. They are scientifically designed to treat wastewater through the interaction of sunlight, bacteria, and algae. They are used for simple secondary treatment of sewage effluents. Within an oxidation pond, heterotrophic bacteria degrade organic matter in the sewage to produce cellular material and minerals. The production of these supports the growth of algae in the oxidation pond. Growth of algal populations allows further decomposition of the organic matter by producing oxygen. The production of this oxygen replenishes the oxygen used by the heterotrophic bacteria. Based on the depth and process they are classified as aerobic, anaerobic and facultative. Anaerobic oxidation ponds are of 8-10 ft deep and take about 1-2 days for the process. Facultative oxidation ponds are generally 4-8 ft deep and aerobic is of depth 3-5 ft. generally. Facultative and aerobic requires more number of days (3-6) [19]. |

| | | |
|---|---|---|
| 5 | UASB | Anaerobic digestion has been broadly recognized as the core of sustainable waste management. The anaerobic sludge blanket (UASB) reactor is the most widely and successfully used high rate anaerobic system for sewage treatment. It has gained a lot of popularity in tropical countries where sewage temperature is rather high, viz. 24–27 C°. UASB is a process in which wastewater flows upward through layer of sludge and is processed by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. Bacteria digest organic material and forms compact dense bio films known as small sludge granules. At the top of the reactor, phase separation between gas–solid–liquid takes place [20], [21], [22], [23]. |
| 6 | SBR | The SBR was operated in a 22-h cycle basis which consists of four distinct modes: fill, react, settle, and decant. At the beginning of each cycle,, a pre-defined feed volume was filled into the mixed liquor remaining in the reactor from the previous cycle. During the reaction phase, the reactor was aerated. After total reaction time of 20 h, the mixed liquor was allowed to settle for 2 h and the clarified supernatant was discharged from the reactor. A sample of treated effluent was collected for analysis. Subsequently, the reactor was filled for next cycle of reaction without any downtime [24]. |
| 7 | BioFOR | In order to provide compact plants and to assure greater treatment efficiency and reliability, biological aerated filtration technique has been developed. Biological Filteration and Oxygenated Reactor (BioFOR) is the aerobic filter with Biolite filter media using attached growth process. The BioFOR process is used primarily for the removal of BOD, TSS and ammonia pollution in secondary and tertiary treatment. Because BioFOR is designed to treat higher organic loadings than conventional systems, the units can accommodate higher filtration velocities. The units allow treatment of soluble pollution and solids separation in one compact reactor, so no secondary clarifiers are necessary. The PLC based control system automates the filter operation.Its key feature is it can enhance primary treatment with addition of coagulants and flocculants. It requires less area and eliminates need of secondary clarifier. There is higher retention and contact time due to cocurrent up flow movement of wastewater and air. BioFOR is a compact and robust system. Two stage high rate filtration is achieved through a biologically active media and with enhanced external aeration [24], [25]. |

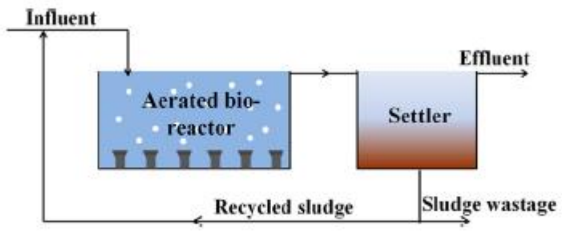


Fig. 1 Activated Sludge Process [16]

**1.4 Tertiary treatment units:** -Tertiary treatment may include a number of physical and chemical treatment processes that can be used after the biological treatment to meet the treatment objectives. It is the next wastewater treatment process after secondary treatment. This step removes persistent contaminants that secondary treatment is not able to remove. Tertiary treatment is the final cleaning process that improves wastewater quality before it is reused, recycled or discharged to the environment. Tertiary treatment is used for effluent polishing (BOD, TSS), nutrient removal (N, P), toxins removal (pesticides, VOCS, metals) etc.

Table 7 Tertiary treatment units with description

| S.No | Tertiary treatment units | Description |
|---|---|---|
| 1 | Activated Carbon Filter | Activated Carbon filter uses adsorption mechanism for the removal of organic micro pollutant from the effluents. The kind and dose of activated carbon, the operational conditions, and the quality and composition of the water all influence adsorption performance. The average clearance rate is 60 to 90 percent, and it is highly reliant on molecular attributes such as charge, hydrophobicity, and size [26]. |
| 2 | Reverse Osmosis | Reverse osmosis (RO) is a membrane-based technology for purifying water or dewatering (separating soluble solids like ions from a solution). It's a diffusion-controlled method in which permeants' mass is transferred via a dense membrane via a controlled solution-diffusion mechanism. The permeants dissolve in the membrane material before diffusing through it. Water will easily permeate into and out of the membrane polymer structure because RO membranes are typically hydrophilic. Because of its ability to reject the majority of dissolved and suspended particles, RO membranes are extensively utilized in water purification and effluent treatment [27]. |
| 3 | Ultra Violet radiations | Ultra Violet (UV) disinfection is a safe and effective physical technology that does not require the use of chemical agents and does not produce disinfection byproducts. These harmful mediators, which are generated when chlorine reacts with natural organic stuff in industrial wastewater, have been linked to an increase in the occurrence of cancer and other significant diseases in people. UV, as a physical process, provides for the reduction of chemical residues dosed for treatment at the treatment plant, such as low residual chlorine concentrations at the discharge, which can be hazardous to aquatic flora and fauna. As a result, UV disinfection for industrial wastewater treatment has established itself as a viable alternative to chemical techniques for secondary and tertiary quality effluents, eliminating toxicity issues and maintaining safety [28]. |

Table 8 Advancement in treatment technologies and their advantages.

| S.No. | Advanced Technologies | Description | Advantages | References |
|---|---|---|---|---|
| 1 | Electrochemical AOP (EAOP) | EAOP is the treatment method which involves the generation of hydroxyl radical which increases the biodegradability of wastewater before it goes to biological process. High oxidizing potential, high reactivity, tendency to attack all organic pollutants, easy generation and short reaction time are some of the properties of hydroxyl radical which makes it useful for the use in treatment of effluents from industries. | Toxic and non-biodegradable contaminants present in the effluent can be effectively removed by this process.<br>Ammonia nitrogen which is difficult to remove by conventional treatments can be successfully removed by this treatment method.<br>Reduction of COD, color, microbes and ammonia is possible thorough this method at optimum conditions. | [13] |
| 2 | Photo catalysis | Photo catalysis process involves the oxidation of contaminants by hydroxyl radical which are produced by excitation of semiconductor using UV radiation which leads to the formation of electron hole pair and finally hydroxyl radical through a sequence of reactions. The most commonly used semiconductor involves $TiO_2$ however doping with iron and platinum ions with addition of cerium ions along with titanium is proved to be efficient nowadays. | It is simple to carry out in typical circumstances.<br>Depending on effluent streams, leads to the total elimination of organic pollutants without the production of any substantial photo-catalyzed hazardous intermediates. It is proved to be environmentally friendly and sustainable treatment method producing 'zero' waste. | [13] |

| | | | | |
|---|---|---|---|---|
| 3 | Phytoremediation | The metabolism of plants is employed to remediate contaminated water in the Phyto-remediation method. The majority of contaminants reach the plant through the roots. Roots provide surface area for absorption and contain a variety of detoxifying mechanisms that can aid in the conversion of toxic pollutants to less harmful compounds. Plants absorb contaminants and store them in their roots, stems, and leaves, after which they undergo detoxification, resulting in less toxic compounds, or conversion into gases that escape by transpiration. | It is a less expensive and more long-term technique of removing pollutants, and it is also environmentally benign because it is founded on the notion of using plants to clean the environment.<br>Phytoremediation is a cost-effective and long-lasting technology that has been successfully used to remove toxic heavy metals such as cadmium, lead, and zinc, as well as organic pollutants such as nitro aromatics and other halogenated hydrocarbons that are poisonous and even carcinogenic to some level. | [13] |
| 4 | Constructed wetlands | Constructed wetlands (CWs) are utilized for wastewater treatment by constructing artificial systems that take advantage of natural processes. CWs remediate effluent using natural processes such as wetland plants, soils, and allied microbes. The majority of emerging countries have a warm temperature, which promotes the expansion of microbial communities. In tropical conditions, these communities thrive, resulting in very efficient breakdown of organic and inorganic contaminants in effluent.<br>Sedimentation, chemical absorption and precipitation, microbiological growth and activity, and reduction of BOD, SS, and nitrogen are all mechanisms involved in the basic operation of CWs. | CWs can effectively remove various organic and inorganic contaminants, like metals as well as micro-pollutants, including a number of pharmaceutical products | [30], [13] |
| 5 | Membrane technologies | Membrane Technologies can be used as pre-treatment to different unit operations or even the other membrane processes.<br>Pressure-driven membrane separations can be divided into four categories-<br>1. Micro-filtration (MF) membranes - These membranes have 0.1-micron pore sizes.<br>2. Ultrafiltration (UF) membranes - 0.010.1-micron pore size<br>3. Nanofiltration (NF) membranes - These have pore sizes of less than 0.002 m.<br>4. Reverse osmosis (RO) membranes - These membranes are non-porous and operate at a high working transmembrane pressure of 150 to 500 psi. | Turbidity, suspended solids and pathogens are effectively removed by micro-filtration.<br>Removal of colour, organic content, viruses, turbidity, suspended solids and other pathogens can be performed through ultra-filtration.<br>NF membrane can affect removal of organic matter, sulphates and also result in water softening.<br>RO involves removal of mono-valent salts along with hardness, color, organic contaminants and various types of bacteria and viruses' removal. | [31], [13] |

## CONCLUSION

The concept of CETP was introduced especially in developing countries to reduce the effluent treatment costs for discrete units, specifically the small-scale industries. But the performance of CETPs especially in India has been unsatisfactory because of numerous reasons. There are problems associated to maintenance, functioning, quality of effluent, cost effectiveness and many more. In many cases, the plant is unable to handle the enormous amount of effluent sent at generated quality by the cluster of industries involved. Thus, various advances in effluent treatment options in a CETP are popular areas of recent research and development. There are technologies that provide better efficiency, are cost effective and more sustainable than the conventional effluent treatment methods, and these methods have been discussed in detail in this review. Some of the important processing units utilized in existing CETPs such as preliminary and primary treatments, chemical and bio-logical treatment processes are initially discussed in the present review.

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