The Overview of Sustainable Technologies for the Treatment of Industrial Wastewater and its Potential for Reuse

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ABSTRACT:

An industrial operation requires some of the systematic process to discharge the effluents, which comprises organic/inorganic/toxic compounds that have been present in the form of dissolved/suspended matter. The amount and quality of industrial effluent vary greatly based on the type of industry that produces it. Depending on wastewater composition, it could be highly biodegradable/non-biodegradable, or include chemicals that are resistant to treatment. The growing prevalence and diversity of synthetic chemicals is a major problem with industrial wastewater. During wastewater treatment, highly complex, putrescible organic particles are partially removed and partially decomposed into mineral or fairly stable organic substances. Conventional treatment methods often need significant energy inputs, extensive land expanses, and high operating and maintenance expenses. Recently, improved wastewater treatment techniques such as membrane technology, electrochemical processes, and oxidation processes have been developed and the treated water from these systems may be reused in a variety of applications, including irrigation and landscaping. In this study, a variety of industrial wastewater sources, treatment methods, and reuse techniques are explored.

Keywords:

Industrial wastewater, Nano technology, Biochemical Oxidation, Activated sludge process

INTRODUCTION:

The Disparate behavior of industrial effluent treatment is used to adjust the pH in the treated Water, removal of oily nature substances like grease particles, removal of metals, biodegradable pollutants and other hazardous substances. There are two major issues has be define treatment and disposal of waste in industries. Most of the growing industries futile in the treatment process and it leads for unwanted ecological degradation. Similarly in disposal of waste from various industries like chemical, pharmaceutical, textile, mining, fertilizer manufacturing, tanning, pulp and paper industry, distillery, food processing are still facing the adaptation of suitable methodology for the removal of organic, inorganic and biological compounds after treatment. This problem will be rectified by furnish with an appropriate innovative ecotechniques. The disposal of complex industrial waste should be treating effectively by introducing ecotechniques. There are Multifarious studies have studied reveals the removal methods of organic and inorganic pollutant from industries. Some of the technique which are in practical is mentioned below.

Some of prescribed methods already discussed in various occasions.

S.No	**Processes**	**Material**	**Advantages**	**Disadvantages**
1	Chemical Deposition Method	CaO, Acid, Base, Surfactants, Sulphide /flocculants,	1.Simple operating method 2. Applicable for large scale operations.	1. Chemicals are very expensive requirement, 2.pH , Precipitant concentration and maintenance is quite difficult
2	Ion exchange Process	Synthetic resins which are mainly cross linked sodium polystyrene sulfonates	1.High treatment capability 2.Higher rate of metal removal	1. Replacement of resin is very costly. 2. not applicable for large scale operations
3	Reverse osmosis techniques	Cellulose acetate, potassium ferrocyanide	1.Effective removal of metals from wastewater	1. High chemical cost. 2.contamination in membrane occurs
4	Membrane filtration Techniques	Cellulose acetate, Cellulose nitrate polyamide and polycarbonate.	1. Reuse of wastewater 2. Recovery of valuable material 3.prevention of environmental damages	1.Membrane contamination occurs 2.High Capital & Maintenance cost 3.Less efficient

5	Coagulation / Flocculation methods	Activated silica, clay alum, ferric sulphate, ferric chloride	1.Applicable to large scale wastewater treatment	1. Large amount of sludge produced and disposal issues occur.
6	Electrolytic recovery process	Electrical energy	1. Lesser chemical consumption 2.Recovery of pure metal, 3.Effective removal	1. Not suitable for large operations. 2. High capital cost of designing and implementing 3. At dilute concentration, energy decreases..
7	Adsorption methods	Activated carbon	1.Highly effective for removing heavy metals to permissible limits	1.High cost 2.Loss of adsorption capacity

1.1 Treatment Options:

Traditional physico chemical techniques of general wastewater treating methods are identified as, Screening, Oxidation (chemical, air), Sedimentation, filtration, Steam Stripping, Coagulation and Precipitation techniques. The recent important uncomplicated method included in this is treatment with Biosorbents. In general these techniques are similar to remove traditional methods to deposited matters, TDS, colloidal impurities, floating matters, colours, and toxic compounds. Basic common process involved in wastewater treatment is split upto 4 stages. In the first stage is mechanical treated of effluent by using sieves and screening methods. In this stage nearly 25% - 35% pollutants removed. In the second stage, secondary wastewater treatment tanks are used to remove biological waste. In the third stage, neutralization, phosphate, and nitrogen elimination, deferrisation, demagnetistion takes place. Finally in the final stage filtration of effluent is done by using various modern filters.

i. **Sedimentation:**

Modern disposal of dissolved solid particles, oily and greasy nature of an effluent is leads for the formation of suspended matter in the wastewater. Total suspended solids (TSS) are removed by using sedimentation tanks. If the sedimentation process is not done proper the resultant is black coloured effluent discharge. Treatment of effluent with the addition of chemicals is effectively to reach the points effectively.

ii. **Adsorption:**

The surface attraction of adsorbent by adsorbate molecules is known as adsorption. There are different easily available adsorbents are used for this method. Among activated carbon being the dominant one may be used to remove the hazardous contents from wastewater. Now a days ecofriendly and easily available low cost adsorbents plays an vital role in the adsorption process. Most of the batch adsorption and column adsorption methods are worn by activated carbons for the treatment of wastewater. The important material takes participation is adsorption-bed. Replacement/regeneration of this adsorption-bed material is too expensive.

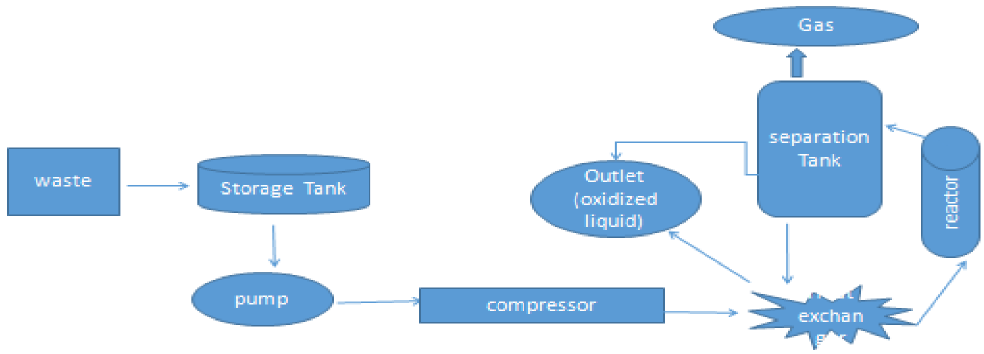
iii. **Steam Stripping:**

In general seam stripping process is used in many of the industries to remove hydro carbons, hydrogen sulphide, phosphine and other volatile organic compounds. Mostly scrubbing or steam stripping process is applicable in treating ammonia in the presence of wastewater particularly in coke. Not only treating ammonia but also have a difficulty to remove the pollutant in the presence of coke wastewater. Adjusting pH is one of major problem in this method. Another important complication is capital investment.

iv. **Wet-Air Oxidation:**

Wet-Air Oxidation is otherwise known as wet oxidation process. This method is place an important to remove organic contaminants such as chemical oxygen demand (COD).Both temperature and pressure are directly proportional to each other during the oxidation process. Salt precipitation leads to causes serious reactor plugging. Construction of salt separator in a correct position can avoid this problem.

A schematic representation of the basic wet oxidation process is represented below.



v. Coagulation and Flocculation:

Flocculation is a physical process used to dissolve the organic particles as sediments to remove from effluents. This process always takes place as an intermediate process. It effectively removes the organic pollutants, total dissolved solids & dissolved particles. The Coagulation is a chemical process using coagulants to collide the pollutants as a solid deposit in the wastewater processing.

In recent days effective management of wastewater treatment process follows advanced oxidation process. This oxidation process includes chemical oxidation followed by Fenton reagent, membrane techniques and ozonation methods. There are different salient features in advanced oxidation treatment. These are very much useful in industrial applications.

i. Ozonation:

Ozone has a high oxidation value. This capacity is used in the colour removing process, removal of COD, BOD, TDS vales in industries. The release of oxygen free radicals strike the organic compounds in industrial water and remove it. It also assaults the presence of microorganisms. But this process needs expensive chemicals like potassium iodide .so it is not preferable by most of the industries.

ii. Chemical Oxidation:

The role of hydroxyl ion present in the oxidizing agent is important to remove all the dissolved particles in chemical oxidation. Maintaining pH is important in this process. In most of the cases Fenton's reagent (H_2O_2 and $FeSO_4.7H_2O$) is prefers due to its reactivity. The organic wastes in the effluent can be busted by this Fenton reagent.

iii. **Electrochemical Oxidation:**

Comparatively Electrochemical oxidation is an ecofriendly and favourable technology in the industrial water treatment process. Most of the refractory treatment process is done by this electrochemical oxidizing method for the removal of phenolic compounds. Nowadays graphite, platinum, anode and Boron-doped diamond (BDD) cathodes are preferable to remove particularly ammonical compounds. The most effective provocation is energy consumption.

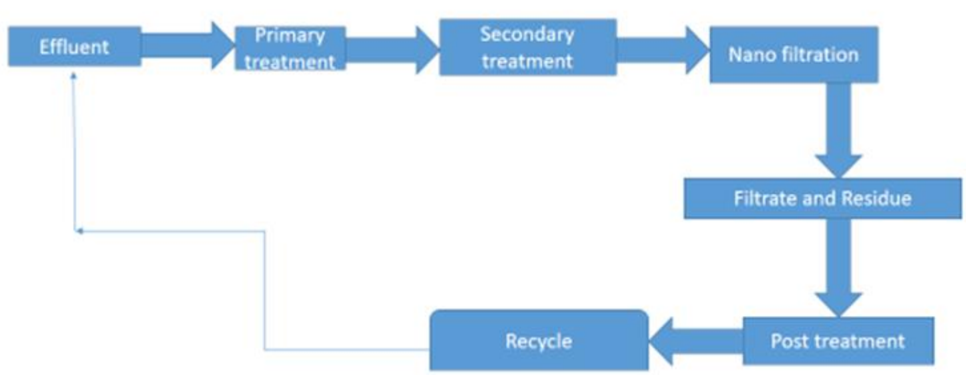
iv. **Electro-Fenton Advanced Oxidation :**

In the chemical oxidation process using Fenton's reagent causes lower oxidation rate and the amount of sludge produced is very high. For this obstacle Electro-Fenton is a process is specifically formulated. The electro-Fenton conquers the oxidation by electrochemically by converting the iron (III) compounds into iron (II) compounds. The oxidation process is again continued by the formed ferrous salt.

v. **Membrane Technology:**

Membrane-based technologies are the materialize techniques used in the industrial water treatment process. There are number choices to place number of membranes. All types of membranes can be planned to place this type of filtration process like Nano filtration (NF), microfiltration (MF), Ultrafilteration (UF) and RO membranes, etc.,

The schematic representation of Nanofiltration process is



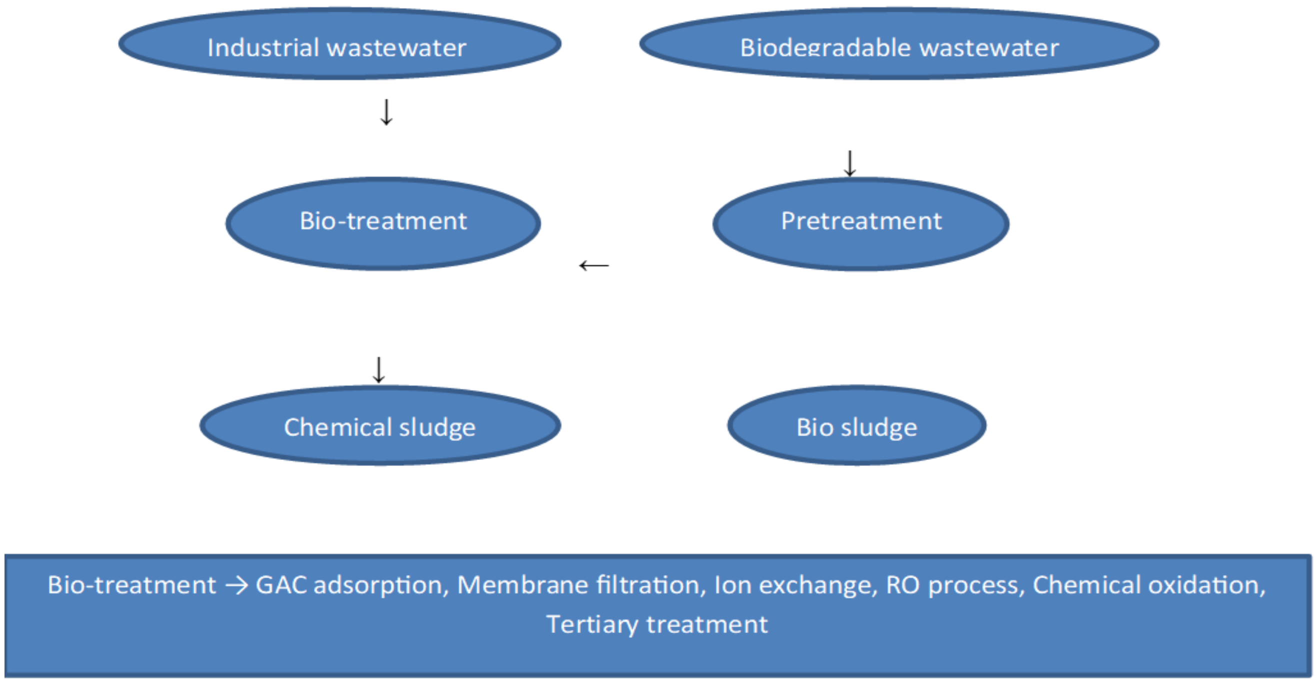
NF membrane is mostly preferable method due to no need of any chemical in functioning, heavy metal and organic reduction, removal of multivalent ions, less amount of waste discharge, less operational cost. Pore radius, Thickness-Porosity ratio and Charge density of the membranes are important specifications in removal process.

vi. Photo catalytic Oxidation:

In the wastewater treatment process, Photo catalytic or photochemical degradation processes are emerging trends due to its complete mineralization at low temperature. The release of photons are not depending the catalyst present in the solution. The free radical mechanism initiated the reaction with sufficient energy of the molecule. UV radiation produces free radicals by simple photochemical degradation of oxidizers.

The source of Free radicals are semiconductors. During photo catalytic mechanism the semiconductor materials produces large amount of free radicals (Bhatkhande et al., 2002; Mazzarino and Piccinini, 1999).simple and ecofriendly, cost effective uv source i.e sunlight is used for large scale applications of treating effluents.(Han et al., 2012; Konstantinou and Albanis, 2004).in most of the cases TiO2, ZnO, ZrO2, and CeO2, or CdS and ZnS have been used as photo catalytic substances (Bhatkhande et al., 2002).Presence of active centers and surface area are the important parameter in the overall degradation process.(Xu et al., 1999). Due to charge separation in Photo catalytic reaction leads for the formation of bandgap in semiconductors (Daneshvar et al., 2003).

The schematic representation of Wastewater treatment methodology is shown below



1.2 Classification of Biological Treatment Processes:

The cultivation of microbial population is deals by its two of the important mechanisms. They are suspended growth mechanism and the attached growth mechanism.

a. Suspended growth mechanism:

Activated sludge process (ASP) is an efficient biological treatment process in which microbes within the aeration tank or bioreactor grow while remaining suspended in the aqueous medium.in the sedimentation tank deposited sludges are continuously treated. The treated sludges with microbes are again and again activated by passing fresh oxygen in the aeration tank. Among the deposits organic deposits are easily decomposed. Some of the chemicals do not completely removed by this ASP. These disadvantages are rectified by using single-step ASP.

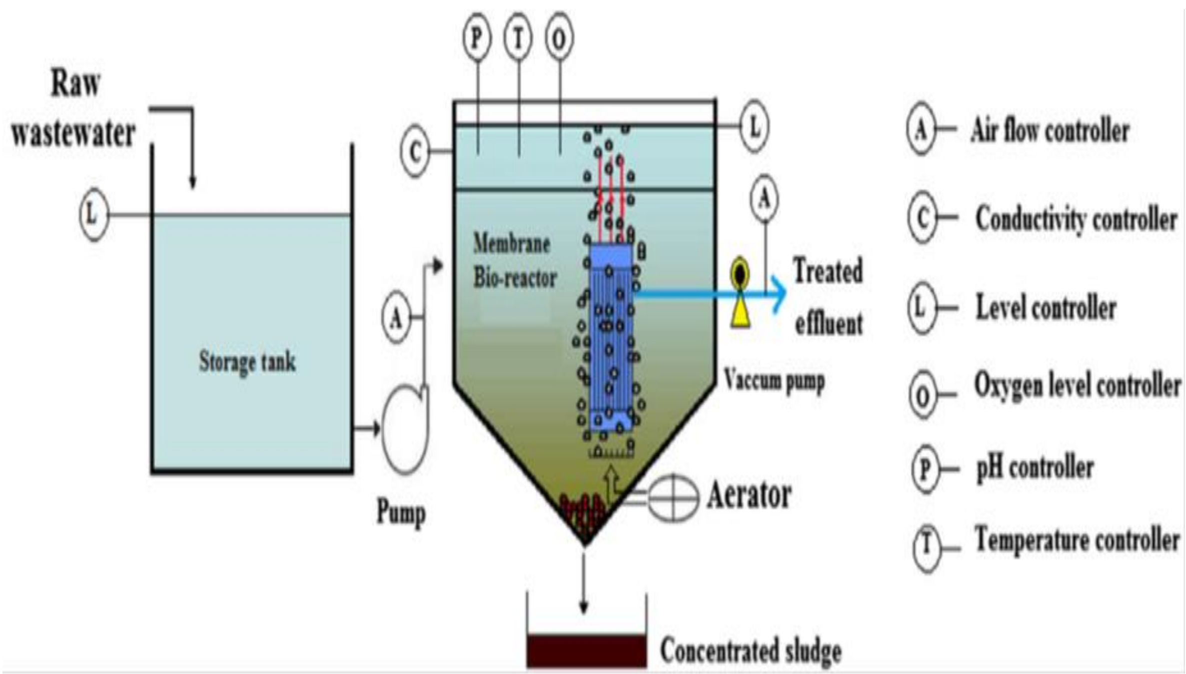
b. Single-step treatment:

The activated sludge unit is constructed by main aerated column accompanied by downstream sedimentation tank. There are several steps takes place in the ASP is Removal of organic matter by adsorption and agglomeration followed by microbial flocculation, subsequent assimilation and finally mineralization by complete oxidation. Mostly the importance consequence in this process is (HRT) High hydraulic residence time and lengthy solid-retention time. Multistep treatment focuses denitrification reaction also.

i. **Biofilm system (BF):**

Biofilm system is the next higher level process to meet over the negligence of ASP. It has higher coherence of removing COD. A biofilm is designed by combining [(anaerobic (A) - oxygen1 (O1)- oxygen 2(O2)] i.e. A-O1-O2 with a cubical structure with micro and macro pores. High level of water content and porous nature of the filtration process removes 92% of COD. In the bottom of the reactor is filled by diffusers which the oxygen supply is diffused. The active center in the biologically aerated filters are submerged in waste water tank. The microbial growth of the film is caused by high surface area of the filter. These microbial films act as bioreactor as well as bio filters making the process quite efficient.

Schematic of membrane bioreactor (Luong TV,et.al., CIRP, 2016;40:419_24.)



ii. **Bio augmented activated sludge process:**

An activated sludge system based on bioaugmentation with specialized microorganisms can be a powerful tool to enhance the efficiency of a wastewater-treatment process through improved flocculation and settling of activated sludge.

The future growth of industries will be decided by the development of novel reactors, reactor configurations, and devices that operate with improved efficiency and reduced cost (capital and operating). This development is indicated by new terminologies such as anaerobic membrane bioreactor (AnMBR), enhanced membrane bio reactor (EMBR), anaerobic migrating blanket reactor (AMBR), membrane biofilm reactor, and sequencing batch bio filter granular reactor (SBBGR).

i. **Nanotechnology:**

In Industrial wastewater treatment Nanotechnology is having a significant role. Nano-materials are also expected to play an important role in the modification of existing adsorbents and catalysts used in wastewater treatment processes. The fabrication of metal nanoparticles have been developed by diverse technique such as thermal decomposition hydrothermal method ,solvothermal method , thermal process , microwave irradiation method , precipitation method , magnetron sputtering , combustion solution method using glycine , laser-induced deposition , sonochemical synthesis , sol–gel synthesis , combustion synthesis, thermal reduction , urea-assisted homogeneous precipitation and precursor calcinations . Chromium (Cr_2O_3) possess specific applied applications such as liquid crystal displays in high-temperature resistant materials , coating materials , corrosion resistant materials , green pigment , solar absorbers , heterogeneous catalysts , ceramics, coatings, printing and paint industry. In contrast with the conventional method, bio synthesis is friendlier to environment because it utilizes plants extract as the chemicals substitute. In industry reusing treated wastewater getting attention in an economical importance.

ii. **Carbonaceous Nano materials:**

The carbon based Nano materials like carbon Nano-tubes, graphene and graphene derivatives are named as Carbonaceous Nano materials. They possessed by high surface area, highly tunable carbon backbone, and hydrophobicity. This property establishes these materials acceptable for the adsorptive removal of cyanobacteria toxins, heavy metals, natural organic matter (NOMs), and dyes. Numerous applications of carbonaceous materials is due to their high surface area, antifouling property, high selectivity, permeability, high flux, porous structure, and antimicrobacterial property.

CONCLUSION:

The importance of industrial growth leads to many societal activates of nation. Therefore care must be taken in the wastewater treatment process and disposal. The ecosystem should be preserved by avoiding passing the industrial wastewater without treating. There were tremendous methods in the wastewater treatment process are discussed. Most of the industrial effluents treating process with special types and its specializations are focused in many industrial related case studies and applications. Now a day, treating an effluent is diminishing the pollutant levels and discharging the amount of pollutants follows the limitations and specifications drawn by central and state board agencies. Interestingly most of industrial wastewater treating process as views in the point of cost effectiveness. Embrace the recycling and reuse of waste water driving many industries reveals that constrains of water scarcity in many of the neighbouring places. Earlier method of discussion gives the better innovative technology to utilize the waste water for both domestic and industrial purposes. It guides to provide the importance of treatment methods besides guidelines for time ahead. The technology results the new guidelines to resolve the issue of water related problems. The state and central government should adhere water related pollution related laws and regulations enforced by them. Likewise laws and regulations merely control the pollution related issues. Each and everyone should have some ethics to follow treatment process where it to be needed. Selection of water treatment method and importance of waste water treatment process is very much needed for future survival.

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