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RESEARCH ARTICLE

CONVENTIONAL AND ADVANCED TECHNOLOGIES FOR BIOREMEDIATION OF WASTEWATER POLLUTANTS

N.D. Totewad[1], Biswaranjan Patra[2] and Suchita Warangkar[3]

1. Department of Microbiology, B. K. Birla College of Arts, Science & Commerce (Autonomous), Kalyan-421301, (M.S.), India.
2. Siksha 'O' Anusandhan, Deemed to be University, Bhubaneshwar, Odisha, India.
3. Department of Microbiology, Netaji Subhash Chandra Bose College, Nanded (M.S.)-431602, (M.S.), India.

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Abstract

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In recent years, industrial as well as municipal wastewater discharges have caused great damage to water resources. Water pollution not only brings about imbalance in the ecological environment, but directly also affects human health. Therefore, there is an urgent need for scientists to develop effective wastewater purify technology to solve these significant issues. It is an essential to control and prevent unsystematic discharge of wastewater into the environment.Few of the reported strategies such as adsorption, filtration, centrifugation, catalysis, biological treatment and electro-coalescence, have been widely applied in wastewater treatment. But heavy energy utilization, non-repeatable usage and emergence of secondary pollution still seem to be inevitable. In this context some of the advanced, effective, and more reliable techniques have been discussed by showing their potency in removing different categories of pollutants which are present in respective type of wastewater. It has been shown that these advanced methods exhibited better performance than those of pre-existing conventional treatment methods with successfully overcoming the limitations associated with them. This review shows the potency of advanced methods which makes them suitable for getting integrated with those of conventional methods or else could be used singly in wastewater treatment plants (WWTPs) to tackle the current scenario.

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Introduction:-

Water, being our life's elixir, possess numerous vital characteristics which are essential for survivability of life processes. Although water covers >70% of the surface of earth, but only ~0.007% of water is accessible for direct human consumption. Thus "consumable/clean water is scarce natural resource." Numbers of industries have been established in past decades, such as automobile industries, textile industries, agriculture industries, cement industries, food industries etc. Thus, their wastewater being rich in various kinds of organic(phenols, endocrine disrupting chemicals, azo dyes, polyaromatic hydrocarbons, polychlorinated biphenyls, pesticides etc)inorganic pollutants(trace elements, mineral acids), xenobiotic/recalcitrant compounds (chloro& nitro phenols, fungicides), heavy metals (Cd, Cr, As, Pb, Hg etc), microplastics (dioxin, persistent organic pollutants), toxic pharmaceutical residues, these untreated/inefficiently treated wastewater can disrupt the fresh water ecosystem when these are made

Corresponding Author:- N.D. Totewad
Address:- Department of Microbiology, B. K. Birla College of Arts, Science & Commerce (Autonomous), Kalyan-421301, (M.S), India.

to release into it. As, most of these pollutants are non-biodegradable in nature, when ingested/uptaken by aquatic organisms, persists in their body for long period of time by the phenomenon bioaccumulation. And when humans are using these waste-laden aquatic organisms (fishes, crabs, tortoiseetc.) for their food, these pollutants are get transferred into them through food chains/food webs and the levels of pollutants will also increase in higher level organisms due to biomagnification.

Water pollution sources can be categorized in to two types. 1) Point source; - it implies to pollutants which enter waterbodies from single and identifiable source (e.g.,effluent pipes of industries, treatment plants etc) and 2) non-point source; - it includes a diffused type of contamination which has not been originated from a distinct identifiable source.

Figure 1:- Different sources for wastewater production.

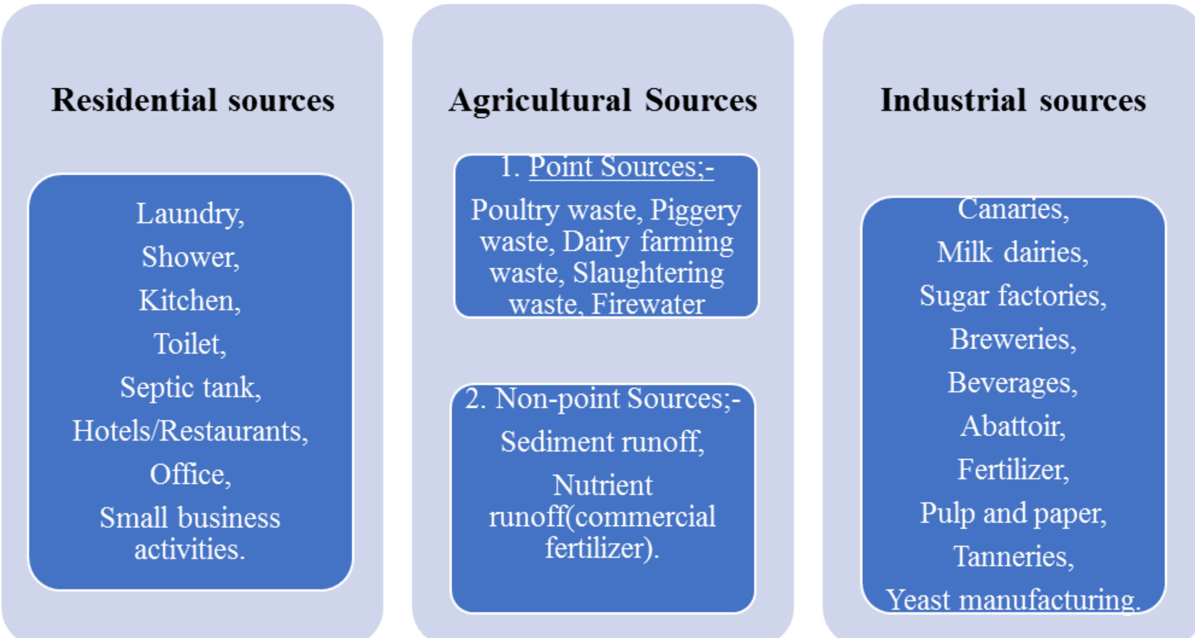


Table 1:- Inorganic and organic water contaminants and their examples.

A. Organic water pollutants		
Sr.No.	**Organic water contaminants**	**Examples**
1.	**By products of disinfection**	Chloroform.
2.	**Detergents**	Several commercially available products.
3.	**Wastes from processing of foods**	High BOD & COD demanding pollutants, grease, fats etc.
4.	**Herbicides& insecticides**	Organohalides
5.	**Petroleum hydrocarbons**	Gasoline, jet fuels, diesel fuel, fuel oil, motor oil etc. (G. Allen and Robert Pitt (2001)
6.	**Volatile organic compounds (VOCs)**	industrial solvents.
7.	**Chlorinated solvents**	Trichloroethylene&Polychlorinated biphenyl.
8.	**Drug pollutants**	Hormonal medicines, antidepressant drugs: contraceptive pills. (The Economist, 2018)
B. Inorganic water contaminants		
Sr.No.	**Inorganic water pollutants**	**Examples**
1.	**Acidity**	sulfur dioxide
2.	**Ammonia**	Various food processing wastes
3.	**Chemical waste**	Industrial by-products
4.	**Fertilizers**	Nitrates and phosphates. (G. Allen and Robert Pitt (2001)
5.	**Heavy metals**	Arsenic, mercury lead etc.

6.	**Silt (sediment)**	Present in construction sites, land burning sites runoffs.

Methods Of Conventional Wastewater Treatment

1. Physical Methods:

These methods involve physical separation of settleable inorganic solids, floating materials, besides oily substances of the wastewater while they are allowed to pass through different physical barriers as screeners, grit chambers, skimmers and finally through clarification in sedementing tanks.

Screening:

A screener is an equipment having openings to separate the floatable and suspended materials. The screeners are classified as coarse(75-150mm), medium(20-50mm) or fine(<20mm), basing upon the sizes of openings.

Grit Chamber:

It is a sedimentation basin placed at the front of wastewater plant to remove sand, eggshells, coffee grounds and other non-putrescible materials that may clog channels or cause abrasive wear of pumps and other devices.

Skimming Tanks

Oily and greasy materialswhich came from industrial and domestic outlets find their way into the sewage, which can be separated with the help of a skimming tank.

Equalization Basin

Equalization of flow levels out the operation factors as like levels of pollutants, flow, and temperatures over a period of time (usually 24 hr), minimizes the downstream effect of these mentioned parameters.

Clarifier or Sedimentation Tank

The settleable solid particles can be allowed to settle down at the bottom of sedimentation tanks if it is allowed to be kept undisturbed for a while after stopping the flow of sewage into it.

Chemical Methods

This method is employed for treating wastewater by employing specific chemical reactions as like, Neutralization, Flocculants and Coagulants, Oxidation, Ion Exchange, Ozonation and Disinfection.

Neutralization

To neutralize, alkaline agents are added to this to increase the pH while simultaneously precipitating the metals.

Flocculants and Coagulants

The job of coagulants is to neutralize the negative charge of particles, that is to destabilize the forces to keep the colloids apart.Flocculants gather-up the particles which have already been destabilized through coagulants to cause them agglomerate and settle down from the solution.

Oxidation

The BOD of wastewater is reduced through oxidation, which may also lessen the harmfulness of few contaminants. Some contaminants are converted into CO_2, H_2O, and biosolid during secondary treatment.

Ion Exchange

Water that is too hard to clean with is very difficult to utilize and frequently leaves a greyish residue. Water hardness is caused by ions such as calcium and magnesium. Cationic sodium ions are supplied to the water in the forms of soluble NaCl salts, or brines, to soften it.

Ozonation

Ozone(O_3), which is used for disinfecting drinking water, removing effluents from the wastewater facilities through a process known as ozonation or ozonisation, and degrading organic and inorganic contaminants in wastewater.

Disinfection
The goal of disinfection in wastewater treatment is to significantly reduce the quantity of the microbes found in the water that will be released back into environment, for later use as drinking water, bathing water, irrigation water, and so on.

Biological Methods
Wastewater treatment by procedure involves biological treatment along with secondary sedimentation. How secondary treatment is characterised. To put it another way, secondary treatment is a biological procedure. The settled wastewater is put into a specifically built bioreactor, where microorganisms such as bacteria (aerobic or anaerobic), algae, and fungus use the organic content under aerobic or anaerobic conditions. The bacteria can proliferate and use the dissolved organic materials as energy in the bioreactor's optimal bio-environmental conditions.

Bioremediation of Wastewater
Treatment which uses natural organisms to breakdown hazardous pollutants to less harmful or harmless compounds" is called as Bioremediation. Phytoremediation, Rhizofiltration, Bioaugmentation, and Bio-stimulation are few examples of bioremediation-related technology. Bioremediators are the microbes that are used to do bioremediation.

Aerobic treatment
To eradicate trace organic compound which are volatile in nature from water, aeration has been utilised. It's also been used to transport a substance, like oxygen, from the gaseous or atmospheric phase into the water in a method known as "gas adsorption" or "oxidation," which oxidises the organic compounds in wastewater. Examples of aerobic treatment includes activated sludge method, rotating biological contactors, trickling filter etc.

Anaerobic Treatment
Anaerobic treatments are used to treat those kinds of wastewaters, which are characterized with having high loads of organic substances (i.e: BOD > 500 mg/L) as well as sediment sludges. Although anaerobic treatments are time-consuming, it offers numerous benefits in the clean-up of strong organic wastewaters.(Table:2)

Table 2:- A collective information on different types of conventional and advanced wastewaters treatment methods.

Type of Wastewater	Major Water Pollutants	Bad effect of health status	Conventional Techniques for Wastewater Treatment	Advanced Techniques for Wastewater Treatment	Efficiency of Advanced Techniques	References
Heavy metals containing wastewater	Lead, chromium, mercury, arsenic, cadmium, copper, nickel, silver, zinc etc.	Kidney pathology, neurological disorders, cancers etc.	Chemical precipitation, flotation, adsorption(by fly ash), ion exchange, electrochemical deposition etc.	Adsorption onto the micro-particle of dried Withania frutescens plants by means of a new adsorbent.	99% removal of lead, 92% removal for cadmium, 91% removal for cupper and 92% removal for zinc.	Chibanet al., (2012).,
Domestic wastewater	Organic matter, nitrogen, phosphorus etc.	Gastroenteritis(diarrhoea or vomiting), cryptosporidiosis(severe stomach cramps), delpetion of dissolved oxygen etc.	Separate physical, biological, and chemical processes.	New-type multiple-layered artificial wetland.	87.9%, 90.6%, 63.4%, 66.7%, and 92.6% respectively for BOD5, CODCr, total nitrogen, NH3-N, and total phosphorus.	Lu et al., (2015).

Dairy industry wastewater.	Suspended and dissolved solids, soluble organics, fats, chlorides, sulfates etc.	Eutrophication, nuisance smell, anaerobic condition etc.	More energy requiring trickling filter, activated sludge process, rorating biological contactors etc.	By combined method of aerated phytoremediation and electrocoagulation process.	97.9% reduction in COD.	(Akanshaet al., (2020))
Deplating wastewater	Silver, copper, total nitrogen etc.	Eutrophication, decreased pH	Ion-exchange, adsorption etc.	An environmentally friendly precipitation-electrodeposition and oxidation process	99.9% of silver ions.	(Gu et al., (2020))
Phenolic Wastewater	Monophenols, binary phenols, and polyphenols etc.	Necrosis, digestive problems, liver & kidney damages etc.	Steam distillation, liquid-liquid extraction, adsorption, biodegradation etc.	Ultrasound-assisted electrochemical treatment,	When ultrasonic treatment time is for 30 minutes, the removal rate of phenol and COD was 92.27% and 82.48%, respectively.	Zhang et al., (2020).
Pyridine and cyanopyridine containing wastewater, phenol and petrolium containing wastewater, textile, and dyeing wastewater.	Recalcitrant compounds(less to non-biodegradable)	Reproductive and developmental toxicity etc.	Biofiltration, aerobic and anaerobic degradation/digestion.	Combination of the Fenton treatment and biological oxidation.	99% COD, 99.7% BOD_7 removal from the plywood industry wastewater.	Trapidoet al., (2017)[9].

Advanced Technologies for Wastewater Treatment

Batch Adsorption Techniques

For treating wastewater, a variety of chemical and physical procedures likecoagulation, chemical precipitation and flocculation, membrane techniques and ion-exchange are available. These technologies are generally linked with significant capital and operating expenses, as well as the development of secondary wastes, which pose treatment issues. As a result, new treatment technologies for removing anions and metal components were required. At low pollutant concentrations, adsorption is among the strategies that is relatively more beneficial and cost-effective. In past few years, enough attention has been showcased for studying various types of affordable substances as adsorbents like: saw dust, tree bark, wood charcoal, red mud, alum sludge, peanut hulls, peat, cocoa shells, corncobs, and waste materials for the adsorption of some toxic substances (Periasamy and Namasivayam, 1995; McKay and Porter, 1997; Reddad et al., 2002; Clave et al., 2004; Meunier et al., 2003; Kadirvelu and Namasivayam, 2001; Cengeloglu et al., 2002). The plant selected to be used as an environmentally friendly adsorbent of wastewater treatment was Withania frutescens plant from the south-western part of Morocco. It’s a shrub having small leathery leaves which belongs to the family of Solanaceae.

To use this plant for adsorption, Withania frutescens plant first needed to be air dried for 2-3 days after their collection, followed by its grinding and finally its sieving to get powders of appropriate sizes. The main functional group found in W. frutescens are polar hydroxyl, aldehyde, and carboxylic acid groups, according to a recent assessment (Chiban et al., 2007) of molecular structure and surface characterisation. SEM(Scanning Electron Microscope) images of W. frutescens micro-particles showed the presence of grains in the structure. Due to the uneven surface of W. frutescens particles, the shape of this substance can assist the sorption of the anions and metallic elements. Thus, it makes possible the adsorption of anions and metallic elements in distinct parts of the material. Hence, basing upon its morphology, and contain of high levels of amino acids and tannins(Chiban et al., 2007), it could be pointed out that these materials present an appropriate outer(surface) profile to retain anions and heavy metals. The treated wastewater through micro-particles of the dried W. frutescens plant fulfils the requirements of World Health Organization (WHO, 2004). A similar promising result are also obtained for phosphate ions and nitrate ions removal.

This adsorption capability could be utilized to design batch adsorption systems for the metallic elements, phosphate and nitrate removal. Such a batch system will be applicable to small industries which generate metallic elements-containing wastewaters.

Domestic wastewater treatment through new-type multi-layer artificial wetland.
Artificial wetland is made up of various groundmasses, such as broken stones and gravels, and aquatic plants. Despite the fact of the history of groundmass, plant absorption, and microbial conversion, which are all part of the unique soil-plant wastewater treatment, for artificial wetland, has spanned more than a century, and especially the research has been underway for above 30 years (Lu et al., 2007; Zhang et al., 2010; del Campo et al., 2014; Konnerup et al., 2009), there is still a lack of comprehensive and in-depth investigation on rural sewage water. As inspired by the simulations on natural wetland, the wastewater purification in a constructed wetland ecological treatment method is achieved with the triple synergistically effects of physical, biological, and chemical interaction in case of natural ecosystem. After filling paddings upto a certain level(like gravels) into a depression with a particular length to width ratio and slope of the surface, various plants are cultivated on the filled bed, which are characterized by favourable treatment performance, high rate of survival, firm water-resistance action, long growth period, a beautiful sight, and higher economic values (such as Zizania aquatica, reed, Acorus calamus etc.). The growing plants, existing animals in the water, paddings, and microbes are then combined to create a unique ecological system with plants and animals. When flowing through the surface and gaps in the filled bed, the wastewater can be filtered, absorbed, deposited, ion-exchanged, assimilated by plants and decomposed by microorganisms, with an aim of achieving high-efficient sewage purifications. The technique presents the adopting artificial wetland system as a treatment process, including: -

1. Organic matter removal(through infiltration, microbial degradation, and precipitation)
2. The Phosphorus removal(absorption, assimilation through plants and microbes)
3. Nitrogen removal(precipitation, filtration, volatilization of ammonia and biological removal)

The process abides by such operating principles as leading domestic wastewater flowing firstly into wastewater sedimentation basin for settlement, and then flowing into influent water storage pond before overflowing and infiltrating into multi-layer filling materials zone through the influent pipes, i.e. enters filling materials zone by the cross wall beneath influent water sedimentation basin, passing from bottom to top through boulder layer, gravel stone layer, coal dust-furnace cinder mixed layer and soil layer for filtration. The overflowing water flows into effluent sedimentation basin through cross wall before overflowing into effluent water storing pond(Lu. et al., 2015).

Results show that when hydraulic load rate reaches 0.44 m^3 per m^2.d and hydraulic retaining time reach 3 days, the effects of removal of CODCr, BOD_5, NH_3-nitrogen, and total nitrogen and phosphate from wetland is reasonably good, with mean removing rates of 90.6 percent, 87.9 percent, 66.7 percent, 63.4, and 92.6 percent, respectively, and effluent CODCr reaching approximately 14.1-30.8 mg/L. As a result, the effluent exceeds quality standards for the resolution of farmland irrigation (GB5084-2005). (Lu et al., 2015)

Combined Aerated Electrocoagulation and Phytoremediation Process
Industries, generating huge amounts of effluent comprises the textile pulp and paper, food processing, distilleries etc.(Chowdhary et al., 2018; Valta et al., 2015). The dairy sectors, which releases 0.2-10 L of effluent per single litre of processed milks (Tchamango et al., 2010; Bazrafshan et al., 2013; Martn-Rilo et al., 2015), is a key matter of concern among the food industries. The biological oxygen demand, chemical oxygen demand, and nutrients levels in dairy industrial effluents are all high (Martn-Rilo et al., 2015; Tchamango et al., 2010; Ahmad et al., 2019). As a result, treating dairy industrial effluent is critical not just for the ecosystem but also for meeting the dairy sector's water needs (Tchamango et al., 2010; Sharma, 2014; Rad and Lewis, 2014; Jagadal et al., 2017; Ahmad et al., 2019). Aerobic biological processes are accessible for dairy sector effluent but necessitates more energy, whereas the anaerobic treatment procedures lead to poor nutrient elimination and necessitate additional effluent treatment (Bazrafshan et al., 2013).

The electrocoagulation (EC) technique, at the other hand, has become a popular approach for treating water and wastewater because it combines the advantages of coagulation, flotation, and electrochemistry (Moussa et al., 2017; Syam Babu et al., 2019a). It's a chemical way of treating wastewater (Smoczynski et al., 2013).Electrolytic reaction on the electrode surface (commonly Al or Fe), formation of coagulants in the water phase and phenomenon of adsorption of the colloidal or soluble pollutant with the assistance of coagulants, and separation through flotation or deposition due to small hydrogen gas bubbles produced at cathode, facilitates the separation are three important phenomenon that occur during an EC process. It also has a broad range of advantages, including ease of installing and maintaining, shorter reaction and residence time, odourless treatments, and ability of treating a extensive range of wastewaters.

According to recent research conducted, adding air to the EC process has a considerable impact over the processes of efficiency (Kumar et al., 2018). Kumar and co-workers (Kumar et al., 2018) performed EC studies for the composite effluent with and without the addition of extra oxygen, finding that the addition of more oxygen resulted in higher colour and the COD reduction. For cleaning-up of arsenic polluted water, Syam Babu et al.(2019b) reported the same.

Bioremediation is indeed a group of technologies that use biochemical pathways to reduce concentrations of a large range of inorganic/organic contaminants using selective plants and microbes on or off-site(Ferniza-Garca et al., 2017). Phytoremediation is a kind of bioremediation technique in which specific plant types are employed to separate, extract, sequester, and/or degrade pollutants in groundwater and soil (Laghlimi et al., 2015; Ribeiro et al., 2016).

A potential solution to treat dairy sector wastewater was discovered to be a combined method of electrocoagulation (EC)-phytoremediation process. For aerated EC studies with a reaction duration of 2 hours, the Al-Fe electrode combination has been shown to have achieved a maximum COD elimination effectiveness of 86.4 percent(Akansha et al., 2020). The combined EC-phytoremediation method for treatment of dairy sector effluent has been shown in a COD reduction of 97.9%. (Akansha et al., 2020)

Precipitation-Electrodeposition-Oxidation Process

Ag-Cu plated plastic parts are now widely employed in various disciplines, including electronic applications and the photographic industry (Cantuaria et al., 2016; Ahmad et al., 2019). Thus, the amount of trash Ag-Cu containing plastics plated parts has risen dramatically in past years. The most prescribed procedure for separating metals and plastics is depleting with mineral acids (typically HNO_3), which is also favourable to later processing. Plastic is recycled after solid–liquid separation, however the Ag–Cu containing depleting effluent requires additional treatment. If such depleting wastewaters along with large nitrate concentrations is released into natural water without processing, the excess nitrate ions discharged into water bodies may have negative health consequences since it can be converted to nitrite inside human body, resulting in methemoglobinemia (Yao et al., 2019). Ion exchanges (Kim et al., 2004; Primo et al., 2009), membrane procedures (Tepus et al., 2009; Chen et al., 2015), and biological denitrifications (Chen et al., 2015; Rivett et al., 2008) are all traditional ways for removing nitrate pollution. Biological denitrification, which is extensively used for home and industrial wastewater treatment (Huo et al., 2017), is a technically mature and cost-effective technology (Duan et al., 2019) among these technologies. However, because to the extreme high levels of total nitrogen content, low pH, and shortage of carbon supply, it is still hard to dispose this category of wastewater via biological nitrogen removal, resulting in high cost.

It is crucial to design an environmentally acceptable technique for separating and recovering Ag^+ and Cu^{2+}, as well as removing COD, torealise wastewater reuse. Chloride precipitation can be utilized to extract Ag^+, which can then be replaced with iron. In view of the high conductivity of genuine depleting wastewater, electrodeposition may be a viable option, as it offers high purity of the product (Guimaraes et al., 2014), high efficiency (Dong et al., 2016; Diaz et al., 2016), less reagent usage (Fogarasi et al., 2013; Korolev et al., 2018), ease of operation (Xu et al., 2004), and a small footprint (Oishi et al., 2007). In terms of Removal of COD, the method should avoid introducing new substances to ensure the integrity of wastewater constituents during the reutilize process.

As a result, an environmentally friendly precipitation-electrodeposition-oxidation method has been devised to concurrently segregate and recover Ag^+ and Cu^{2+} ions, eliminate COD, and reuse the wastewater for depleting the plastic plated part. Furthermore, the wastewater's low pH can be retained during electrodeposition process, and the water can be utilised for depleting plastic plated portions following COD removal via H_2O_2 oxidation at the final step.

Ultrasound-assisted Electrochemical Treatment

The problems associated with water pollution is growing increasingly serious with the tremendous development of industries, particularly the rapid increase of the chemical industries. The release of organic contaminants, like phenolic compounds, has been at the top of the list. Degradation and recycling are the two basic ways for treating phenolic wastewaters. The combinations of ultrasonic technologies and electrochemical 3D electrode-electro-Fenton method is known as ultrasound assisted electrochemical methods (Zhang et al., 2015; Wang et al., 2017). The "Fe" on anode electrode loose 2 electrons in the process of oxidation and is transformed into ferrous ions(Fe^{2+}), whereas the oxygen present on the cathode electrode undergoes reduction process to acquire electrons and become hydrogen peroxide (H_2O_2). Ultimately, the reaction creates an efficient hydroxyl radical, and the properties of hydroxyl radicals are being used to induce and control the process.

Ultrasonic technologies are emerging type of water treatment technologies that are highly efficient and emits no or very little pollutants. Ultrasonic technology combines enhanced oxidation, supercritical oxidation, pyrolysis, and other processes. Organic contaminants in water can be rapidly degraded into carbon dioxide, inorganic ions, water, or organic chemicals that are less hazardous and easier to decompose unlike the original organic substance. It offers considerable benefits for treating difficult-to-biodegrade organic contaminants. Cavitation created by ultrasound has a significant power to breakdown organic waste in the sewage treating processes, and the pace of degradation is rapid. The ultrasonic cavitation bubbles collapse, releasing enough energy to disrupt chemical bonds. When a cavitation bubble collapses, hydroxyl groups (-OH) and the hydrogen groups (-H) are formed, which can oxidise organic matters found in the water and transform hazardous organic matter into CO_2, H_2O, organic molecules, or inorganic ions that are less harmful and degradable than that of the original organic matters. In addition, after wastewater treatment, ultrasonic waves can break up any remaining bacteria in the wastewater and eradicate the sludge's unique odour.

On one hand, ultrasound treatment can decrease concentration polarisation induced by organic contaminants' mass transfer and dissemination (Wang et al., 2017). Around the same time, the ultrasonic cavitation-generated instantaneous greater temperatures and high pressures can invoke the reactant and electrode floor, providing the activation energy for electrode reactions, eliminating electrochemical polarisation, promoting electron transfer in between the electrodes and reactants, and finally speeding up the electrode reactions (Yuanna et al., 2014; Xianzhen et al., 2016; Wang et al., 2015; Zhou et al., 2007; Zuo et al., 2014). As a result of the synergistical coupling of the two effects of ultrasound and electrochemistry, the electrochemical processes can be accelerated and eventually resulting in formation of inorganic ion, CO_2, and water (Zuo et al., 2014; Xianzhen et al., 2016; Tang et al., 2014; Xianzhen et al., 2018; Koryo et al., 2013).

Fenton Treatment and Biological Oxidation

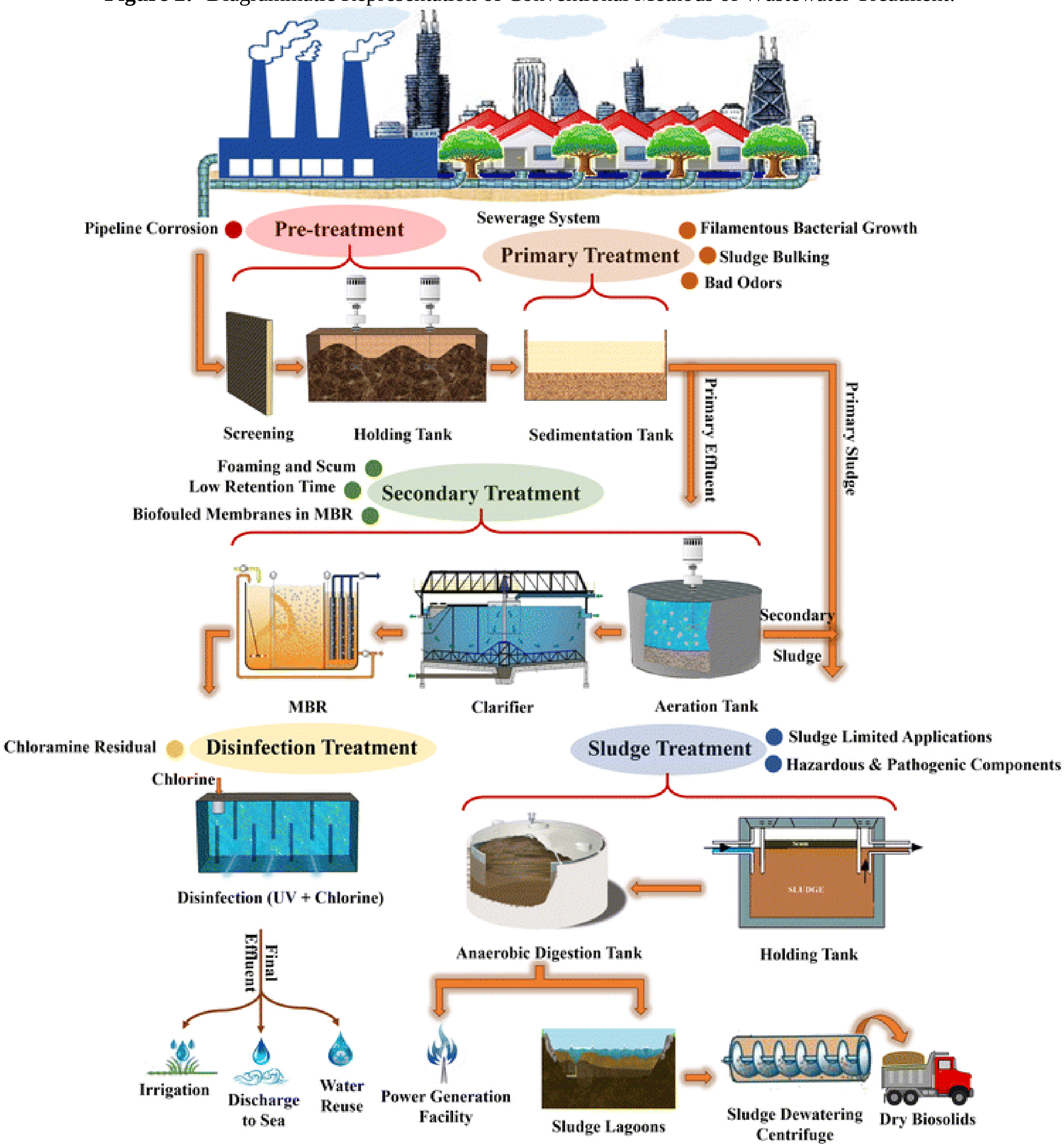
In today's wastewater treatment plants, biological treatments, which eliminates only high biodegradable toxins, is commonly utilised as a standard approach. Some wastewaters, on the contrary, contain substances that are hazardous and/or bio-recalcitrant to biological communities, and which do not degrade during secondary treatment or by microbes present in the waterbodies. As a result, bio-recalcitrant chemicals that build up in water and bottom sediment have an impact on aquatic species and overall ecological balance.

Among the various advance oxidation techniques (AOTs), the Fenton processes and its modifications were got to being effective in the degeneration of a broad range of organics existing in industrial effluents, leading to a high grade of eradication of bio-recalcitrant substances (Bautista et al., 2008; Comninellis et al., 2008), partial mineralization, and a notable improvement in biological degradation in the following biological treatment stage. As a result, the application of a Fenton pre-treatment phase in combination schemes principally focuses on improving bio decomposability and decreasing toxicity to a level where biological treatment is no longer feasible (Stasinakis et al., 2008; Oller et al., 2011; Babuponnusami et al., 2013; Wang et al., 2016). Due to its significant potential for producing hydroxyl radicals, ease of set-up, comparatively cheap total cost, low energy usage, and other factors, the Fenton treatment was chosen as chemical oxidation process (Bautista et al., 2008; Comninellis et al., 2008; Stasinakis et al., 2008; Oller et al., 2011; Babuponnusami et al., 2014; Wang et al., 2016). The inhibitory influence on the activated sludge treatments in strong wastewaters could be the key obstacle for productive bio-treatment use.

Therefore, the Fenton process is frequently advised as the first step in a multiple-step treatment plan, principally to reduce toxicity and improve biodegradability of the raw wastewaters.

Following the biological treatment, the Fenton process allowed for reduction in number of hydrogen peroxides and catalyst necessary for treating the wastewater, lowering the Fenton treatment expenditures. As a result, the ultimate biological method for BIO-Fenton treated effluent can be employed as a pre-treatment process to obtain the needed effluent quality.

Figure 2:- Diagrammatic Representation of Conventional Methods of Wastewater Treatment.



[Schematic diagram of treatment process of domestic wastewater illustrating different stages of water and sludge treatment along challenges associated with it (colored circles).]

(https://www.researchgate.net/figure/Schematic-diagram-of-domestic-wastewater-treatment-process-illustrating-different-stages_fig1_322745587) [accessed 30 May 2021]

Conclusion:-

Contamination/pollution of water is a serious issue which has gained the global attraction in past decades. If left unnoticed, it will have tremendous impact on every living organism and their surrounding environments as well. Wastewater treatment, which is a most effective strategy to counter water pollution, because wastewater treatment operates at the source itself(i.e.,acting at point sources like industrial effluent outlet etc.), appears to be an only plausible solution to tackle pollution to occur. Thus, researchers across the globe had put their hands together for developing wastewater treatment methodologies. No matter different conventional treatment schemes/methods had already been developed, which are in current use in almost each country throughout the globe. But, by the time these methods required to be upgraded to handle present day advanced wastes, which are the results of new manufacturing practices. More energy requirementsin case of aerobic treatments likerotating biological contactors, activated sludge processes etc), skilled personnel requirements (incase of sequencing batch reactors), more area consumption(in case of all conventional treatment methods), more manpower requirement, excess sludge handling and secondary pollutants formation are the main limitations which demand advanced treatment methods.

In this review context, few of the advanced techniques have been discussed showing their ability in handling variety of pollutants effectively, large pollutant load and high wastewater volume while simultaneously being cost-effective, compact/less area requiring, maintaining disposal level water parameters and energy effective. Thus, these advanced methods highly demand to get integrated with conventional methods or else to be utilized singly for better treatment achievement. Although these proposed methods are showing great potentiality for treating wastewater, large scale or pilot scale implementation needed to be performed to ensure their effectiveness.

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