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# WASTEWATER TREATMENT USING CATALYTIC ADVANCED OXIDATION

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*Abstract:* The processes of Advanced Oxidation are related to a methods and reactions which are use hydroxyl radicals OH. as reactive oxidative species. Catalytic Advanced Oxidation is innovative approach to ecological method of waste water remediation and to other challenges that currently represent major unsolved pollution problems. It combines use of the cleanest chemical - hydrogen peroxide $H_2O_2$ with Catalyst capable of incomparable generation of hydroxyl radicals. Hydroxyl radicals are much more powerful than the hydrogen peroxide alone. Hydrogen peroxide is an ideal tool for water purification, because it does not introduce any harmful chemicals such as bleach or chlorine and decompose into water and oxygen.All types of organic matter (e.g. invasive or toxic algae, blue-green algal blooms, animal or human organic waste) can be remediate and sterilized by this reaction. The process finalize in mineralization of the organic effluent with formation of a small amount of mineralized sediment, which can be easily separated. There is no need for introducing acidic or alkaline change in pH. After the treatment and filtering off the sediment, clean, sterilized water with pH 7 is obtain. The process achieve dramatic reduction of COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand). COD is a measure of organic pollution in water, and therefore COD’s allowable levels in the wastewater need to be achieved in wastewater.

**KEYWORDS: Hydroxyl Radical, Organic Matter, Hydrogen Peroxide, Catalyst**

## I. INTRODUCTION:

Clean water is crucial commodity. However, the availability of a clean water is in the increasing jeopardy with the progression of industrializations (especially in the developing countries) and the effective wastewater remediation becomes more and more essential.

The problem is enhanced by the facts that many chemical or pharmaceutical plants produce more and more chemicals which are not only toxic and should not be dumped into the global water resources, but they are also chemically stubborn and resistants to typical wastewater treatment. The main problem of these pollutant is their resistance to oxidative reactions i.e high reduction potential. Degradation of these chemicals (such as aromatic compounds, phenols, benzene, toluene, azo-molecule etc.) require oxidative agents having a very high oxidation potential in order to be effective.

**Advanced oxidation processes (AOPs)**, in a broad sense, are set of chemical treatment procedures designed to remove organic (and sometimes inorganic matters) materials in water and wastewater by oxidation through reactions wastewater treatment, however, this term usually refer more specifically to a subset of such chemical processes that employ ozone ($O_3$), hydrogen peroxide ($H_2O_2$) and/or Ureaction One such type of process is called in situ chemical oxidation.

AOPs rely on in-situ production of highly reactive hydroxyl radicals (·OH). These reactive species are the strongest oxidants that can be applied in water and can oxidize virtually any compound present in the water matrix, often at a diffusion-controlled reaction speed. Consequently, ·OH reacts unselectively once formed and contaminants will be quickly and efficiently fragmented and converted into small inorganic molecules. Hydroxyl radicals are produced with the help of one or more primary oxidants (e.g. ozone, hydrogen peroxide, oxygen) and/or energy sources (e.g. ultraviolet light) or catalysts (e.g. titanium dioxide). Precise, pre-programmed dosages, sequences and combinations of these reagents are applied in order to obtain a maximum •OH yield. In general, when applied in properly tuned conditions, AOPs can reduce the concentration of contaminants from several-hundreds ppm to less than 5 ppm and therefore significantly bring COD and TOC down, which earned it the credit of “water treatment processes of the 21st century”.

The AOP procedure is particularly useful for cleaning biologically toxic or non-degradable materials such as aromatics, pesticides, petroleum constituents, and volatile organic compounds in wastewater.Additionally, AOPs can be used to treat effluent of secondary treated wastewater which is then called tertiary treatment.The contaminant materials are largely converted into stable inorganic compounds such as water, carbon dioxide and salts, i.e. they undergo mineralization. A goal of the wastewater purification by means of AOP procedures is the reduction of the chemical contaminants and the toxicity to such an extent that the cleaned wastewater may be reintroduced into receiving streams or, at least, into a conventional sewage treatment.

Although oxidation processes involving ·OH have been in use since late 19th century (such as Fenton's reagent, which was used as an analytical reagent at that time), the utilization of such oxidative species in water treatment did not receive adequate attention until Glaze et al.suggested the possible generation of ·OH "in sufficient quantity to affect water purification" and defined the term "Advanced Oxidation Processes" for the first time in 1987. AOPs still have not been put into commercial use on a large scale (especially in developing countries) even up to today mostly because of relatively high associated costs. Nevertheless, its high oxidative capability and efficiency make AOPs a popular technique in tertiary treatment in which the most recalcitrant organic and inorganic contaminants are to be eliminated. The increasing interest in water reuse and more stringent regulations regarding water pollution are currently accelerating the implementation of AOPs at full-scale. There are roughly 500 commercialized AOP installations around the world at present, mostly in Europe and the United States. Other countries like China are showing increasing interests in AOPs.

## II. REVIEW OF LITERATURE

Water-Quality Engineering M. Sievers, in Treatise on Water Science, 2011 Advanced oxidation processes (AOPs) received increasing interest in both science and practice of water and wastewater treatment during the last few decades due to their potential of conversion of anthropogenic and biorecalcitrant organic pollutants to biodegradable compounds together with potential of disinfection, decolorization, and deodorization. A prerequisite for safe application of AOPs is the avoidance and minimization of by-product formation and therefore each particular application needs feasibility and validation studies in laboratory and pilot scale before application.

Assuring Purity of Drinking Water K.G. Linden, M. Mohseni, in Comprehensive Water Quality and Purification, 2014 AOPs are used similarly to other drinking water treatment processes such as membranes, granular activated carbon, air stripping, and biological degradation. (The reader may want to review the Chapter 2.4). AOPs have a number of advantages over these other advanced treatment processes used to treat chemical contaminants in water. Table 3 presents a summary of advantages and disadvantages of AOPs.

Remedial technologies for future waste management Prachi Upadhyay, Sankar Chakma, in Hazardous Waste Management, 2022 Advanced oxidation processes (AOPs) mainly depend on the generation of highly active hydroxyl radicals for effective wastewater treatment. Wastewater from different types of industries containing organic and inorganic pollutants is converted into their less-toxic forms that is, small chain acids, $CO_2$, simpler ions, etc. (Adewuyi, 2005). AOPs can be either homogeneous (in the presence of $O_3$ or $H_2O_2$) or heterogeneous (in the presence of some catalyst).

Recent trends in the detection and degradation of organic pollutants Preetismita Borah, Pooja Devi, in Abatement of Environmental Pollutants, 2020 Advanced oxidation approaches

Advanced oxidation approaches are foremost, favorable, effective, and eco-friendly methods which remove the POPs from each type of water. Normally these approaches are depended on the capable oxidative such as hydroxyl radicals (•OH) (Mehmet and Aaron, 2014). It is suggested that these methods are applied for degradation and conversion of organic pollutants by treatment of water or wastewater.

## III. CATALYTIC ADVANCED OXIDATION:

The Catalytic Advanced Oxidation process cleans and disinfects water without introducing any harsh chemicals and does not affect solution pH (unlike Fenton reagents). The catalyst is heterogeneous, which means that it will not be dissolved in water and can be removed and reused. Hydroxyl radicals are very short-lived (of the order of nanoseconds) and therefore they do not remain in the effluent after treatment – their excess is annihilated as oxygen gas generation. Catalytic Advanced Oxidation reduces organic pollutants and toxic chemicals, eliminates odors and colors, sterilizes and disinfects effluents by attacking pathogenic microorganisms and bacteria.

$$2H_2O_2 \longrightarrow 2H_2O+O_2$$

$$H_2O_2 \longrightarrow 2{\bullet}OH$$

$$\text{Organic Pollutants} \xrightarrow{\boxed{{\bullet}OH}} \text{Degradation Products}$$

Catalysts have been found as an important tool for waste minimization and pollution prevention. A catalyst is commonly defined as a substance that changes the rate of chemical reaction without being substantially consumed or changed in the process. Catalysts accelerate reaction rate toward chemical equilibrium to improve the process economically by decreasing activation energy. Catalysts are also known as "green chemicals" that reduce the use and generation of hazardous substances. A careful selection of catalysts allows us to complete a chemical process with zero waste. The commercial feasibility and inherent greenness of any catalyst depend on the selectivity, turnover frequency, and turnover number of that particular catalyst. The use of catalysts has attracted much attention from researchers because it shows the biggest potential of advancement. Literatures show that various catalysts can be used in different conventional AOPs to minimize the operating cost. To date, different catalysts have been identified as potentially useful for AOPs in waste management.

Catalysts are generally divided into two types: homogenous and heterogeneous catalysts. In a homogeneous reaction, the catalysts are in the same phase as the reactants and they are uniformly distributed within the reaction medium. Therefore, the reaction takes place within the liquid, as the catalyst is dissolved in the reaction medium. Heterogeneous catalysts are used in a phase different from the reactants and the reaction occurs at gas-solid or liquid-solid interfaces .A heterogeneous catalyst is also referred to as a surface catalyst, as the reactions take place on the surface of the catalysts, externally or internally within the pores of the catalysts.

## IV METHODOLOGY

1) Highly polluted organic matter wastewater with high percentage of BOD and COD were collected from industry.
2) Firstly the sample of wastewater were taken into the beaker.
3) 7wt% of hydrogen proxide were added into the beaker in which we have taken the wastewater.
4) Small quantity of catalyst were added into the water sample.
5) Catalyst is heterogeneous it forms hydroxyl radical when added with hydrogen peroxide.

$$2H_2O_2 \longrightarrow 2H_2O+O_2$$

$$H_2O_2 \longrightarrow 2\bullet OH$$

$$\text{Organic Pollutants} \xrightarrow{\boxed{\bullet OH}} \text{Degradation Products}$$

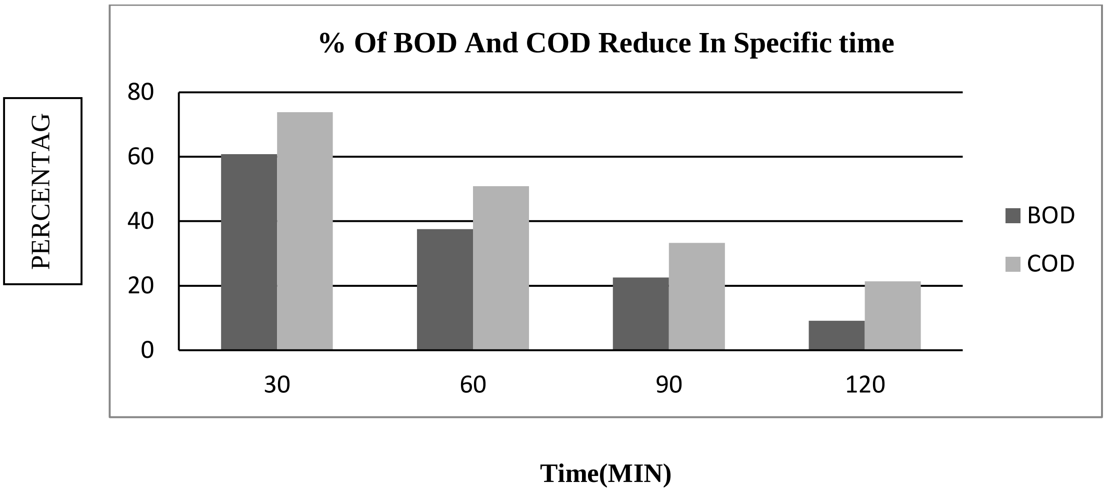
6) The hydroxyl radical as astrong oxidant starts degrading the organic pollutants.
7) The first sample after after 30 minutes were taken out to check how much BOD and COD were reduced at that time interval.
8) Same procedure done till 2hrs.After 2hrs we got the clear water with 7 pH .
9) The percentage of BOD and COD was reduce to the very low level.

## V. APPLICATIONS

1) Advanced Oxidation Processes (AOPs) are the techniques employed for oxidation of various organic contaminants in polluted water with the objective of making it suitable for human consumption like household and drinking purpose.
2) AOPs use potent chemical oxidants to bring down the contaminant level in the water
3) These processes are also capable to kills microbes (as disinfectant) and remove odor as well as improve taste of the drinking water.
4) AOPs cause loss of biological activity of the pollutant present in drinking water without generation of any toxicity.
5) Conventional ozonation and AOPs can inactivate estrogenic compounds, antiviral compounds, antibiotics, and herbicides.
6) They can effectively eliminate organic compounds in aqueous phase, rather than collecting or transferring pollutants into another phase.
7) Due to the reactivity of ·OH, it reacts with many aqueous pollutants without discriminating. AOPs are therefore applicable in many, if not all, scenarios where many organic contaminants must be removed at the same time.
8) Some heavy metals can also be removed in forms of precipitated $M(OH)_x$.
9) In some AOPs designs, disinfection can also be achieved, which makes these AOPs an integrated solution to some water quality problems.
10) Since the complete reduction product of ·OH is $H_2O$, AOPs theoretically do not introduce any new hazardous substances into the water.

## VI. RESULT

| TIME(MIN) | BOD(mg/l) | COD(mg/l) | BOD(%) | COD(%) |
|---|---|---|---|---|
| 0 | 120 | 210 | 100 | 100 |
| 30 | 73 | 155 | 60.8 | 73.8 |
| 60 | 45 | 107 | 37.5 | 50.9 |
| 90 | 27 | 70 | 22.5 | 33.3 |
| 120 | 11 | 45 | 9.1 | 21.4 |



## VII.CONCLUSION

The occurrence of contaminants in drinking water is a major health concern. AOPs based technologies for the oxidation of a wide range of organic compounds have been successfully employed for treatment of these contaminants.

Although AOPs generally result in loss of biological activity of the parent compounds, toxic potential of some transformation products cannot be ruled out.

Multiple classes of drinking water contaminants such as halogenated compounds, olefins, nitro compounds, ethers.

Catalytic Advanced oxidation technologies represent a powerful option for the removal of organic pollutants in industrial wastewater. Different AOPs have been investigated, and thus, it allows the selection of the most suitable process for the specific wastewater treatments.

Different photochemical AOPs also have much potential for the reduction of organics in wastewater. The combination of UV and radicals (hydroxyl or sulphate) can effectively eliminate the organics with higher removal efficiency than direct UV photolysis or persulphate oxidation alone. Decolorization of malachite green oxalate was performed with different homogeneous and heterogeneous AOPs. The influence of ferrous ions and oxidant concentration and comparative assessment of different photochemical AOPs are reported. 12 mM of H2O2 and 60 mg/L of ferrous ion concentrations have been observed to be optimum in the photo-Fenton process. In the comparative assessment studies of photochemical AOPs, the percentage dye decolorization efficiency has been decreased in the order: UV/Fe2+/H2O2 > UV/H2O2/TiO2 > UV/TiO2 > UV/H2O2 > UV alone. The experimental results show that the MGO dye removal efficiency from wastewater is higher in the case of sulphate radical-based AOP than hydroxyl radical-based AOP. Although the pure form of TiO2 is a well-liked photocatalyst for many reasons, it suffers from lower efficiency for photochemical oxidation and becomes deficient in the visible light activity that obstructs its practical applications. Thus, the surface-modified TiO2 photocatalysts have been continuously investigated to overcome the shortcomings of pure TiO2.

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