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A REVIEW ON ELECTROCHEMICAL ADVANCED OXIDATION PROCESS TO TREAT FISH MEAL INDUSTRY WASTEWATER

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ABSTRACT: Fish meal processing industries turns the raw fish into a commercially edible form. The wastewater generated from this industry consists of organic pollutants BOD, COD, Total solids, high amount of odour. Since the industry process the raw fish the wastewater has high amount of COD. Normally in the fish meal processing industry they use chemical and biological methods to treat the wastewater, by adopting these methods for treatment, high amount of sludge is produced after the treatment process is over. Again we have to find another method for disposing the sludge. By using the advanced oxidation process we can eliminate the sludge production during the treatment process. Advanced oxidation process can be done using uv/H_2O_2 method, ozone based AOP, photocatalytic oxidation with TiO_2, electrochemical advanced oxidation process. In all the above mentioned process the pollutants are targeted using different parameters such as UV rays, H_2O_2, electricity. However by using hydrogen peroxide, ozone, UV the complete reaction will not take place and the intermediate products remains in the water as pollutant To overcome this problem Electrochemical oxidation method can be adopted. This method is useful in breaking the most resistant organic compound.

Keywords:
Electrochemical Advanced oxidation process, Boron Doped Diamond, Organic Pollutants, BOD, COD.

1 Introduction

Fisheries play a very important role in making livelihood of millions of people around the world. In India the fisheries sector provides employment for about 14 million people and also contributes 5.23% of GDP to agriculture (source-national fisheries development board). India has the long coastal line of about 8129 Km with 3829 fishing villages. The main occupation of people living in these areas is fishing. India's total fish production is about 8.8 million tons (FAO 2011) and also India is the major supplier of fish in the world (as per central institute of fisheries and technology 2008). Fisheries and aquaculture plays a vital role around the world giving employment for about 60 million peoples.

There are thousands of industries which are used for culturing, processing, preserving, storing, transporting, marketing or selling the millions of fish. These industry produce the wastewater which when discharged without treating will produce enormous problems to human beings, environment and also to marine system. So it mandatory to treat the wastewater and achieve the standards before releasing it into the environment.

Advanced nanotechnology, sometimes called molecular manufacturing, is a term given to the concept of engineered nanosystems operating on the molecular scale. The countless examples found in biology can produce sophisticated, stochastically optimized biological machines, and it is hoped that developments in nanotechnology will make possible their construction by some shorter means, perhaps using biomimetic principles.

2 CHARACTERISTICS OF WASTEWATER FROM FISH MEAL PROCESSING INDUSTRY

pH range of wastewater

pH is one of the important parameter which indicates the acidic or alkaline nature of the wastewater. It also shows the proteinaceous decomposition and ammonia emission (Gonzalez et.al 1996). Usually the ph range of seafood processing is around neutral (sherly et.al, 2015). In a fish processing industry located in Malaysia the raw wastewater has a pH in the range of 6.65 ± 0.02 (Yun Chen Ching et.al. 2017). The fish meal production industry located in Talcahuano, Chile has the pH range of 6 to 9 (Maria dinaafonso et.al. 2002).In an another study the wastewater samples were taken from 22 different sea food processing industry and their pH ranges from 3 to 11 (Miroslav Colic et.al 2007). The raw fishmeal wastewater located in Korea has the pH of about 6.86 (Jang Ho et.al. 2018). The fish industry located in Greece has the pH in the range of

6.13 to 6.75 (Ioannis S. Arvanitoyannis et.al. 2008)

Importance of Biochemical oxygen demand

Biochemical oxygen demand is the oxygen required for the microorganisms to oxidize the organic matter present in the wastewater or effluents. In fish processing industry Primarily the BOD originates from the carbonaceous compounds which are used as substrate for microorganisms and secondarily from the nitrogen compounds like protein, peptides etc. (Sherly et.al, 2015). Usually the BOD has a incubation period of five days at 20ºC (Yun Chen Ching et.al. 2017).
Dilution method with incubation period of five days is used to find the BOD level in wastewater released from the fish processing industry in Malaysia which was found to be 150mg/l (Yun Chen Ching et.al. 2017). The fish meal plants were reported to produce the BOD as high as 30,000 mg/l, pacific whiting processing unit produces around 6000 mg/l of BOD (Miroslav Colic et.al 2007). The carbonaceous oxygen demand(CBOD) and nitrogenous oxygen demand(NBOD) were found in the raw fish meal wastewater located at Korea which was found to be 342.2mg/l and 137mg/l respectively also the theoretical BOD in that wastewater was 479.2 mg/l. (Jang Ho et.al. 2018). The fish processing industry located in Kerala, India was found to have the BOD of about 5100 mg/l (Neena Sunny et.al. 2013)

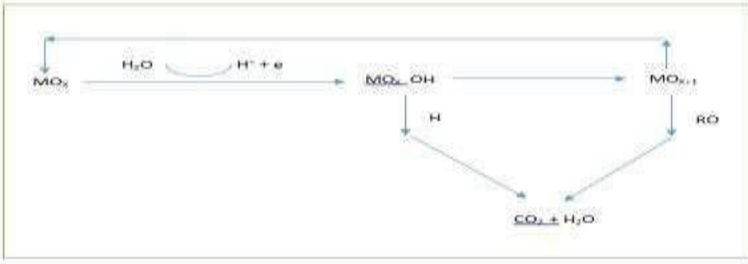
Influence of Chemical oxygen demand

Chemical oxygen demand is another way of measuring organic content present in the wastewater. There are two methods of estimating COD, one by means of chemical oxidation using permanganate another by chemical oxidation using dichromate ion. The COD analysis by dichromate method is more frequently used in wastewater treatment systems (wastewater treatment in fishery industry-ISBN 92-5-103788-4). COD of effluent is always greater than BOD since the number of components that can be degraded chemically is always greater than of components that can be degraded biologically (Sherly et.al, 2015).

3. EXPERIMENTAL PROCESS

Electrochemical Advanced Oxidation Process

In electro oxidation process pollutants are removed by two methods 1) Direct electrolysis 2) indirect electrolysis In direct electrolysis the pollutants are first adsorbed on the anode surface. Then the pollutants present on the anode surface gets oxidized. The required oxygen is produced from the water. In indirect electrolysis the pollutants are not directly adsorbed on the anodic surface instead they are oxidized by the chemically produced redox reagent. The mechanism of how pollutants react with metal electrode is given below



Oxidation of pollutants with metal electrode

The conventional methods such as physical, chemical, biological methods have been used to treat the wastewater from fish processing industry and their reuse possibilities has been discussed. The results shows that the water can be discharged in environment but the reuse of water were restricted to purpose like recharge of aquifers and hydro sanitary facilities (Ribeiro, F.H.M. & Naval, L.P 2017)The removal of Butylatedhydroxyanisole from food and pharmaceautical industry wastewater were carried out using Electrocoagulation and electro oxidation process. The result shows that the electrocoagulation is not good method to remove the Butylatedhydroxyanisole compound whereas electro oxidation is good in removing the BH compound (Zhihong Ye et.al 2019) Various types of Advanced oxidation process have been studied. Each method are suitable treating different kinds of pollutants such that electro oxidation process is suitable for treating large volumes of organic wastewater. Also the main challenges in this method is the cost of electrodes and use of renewable resources. (Ignasi sires et.al 2014).Different types of anode such as Ti/Pt, Ti/Pb0_2, were in Electro oxidation process to treat the effluent coming out of the tannery industry. The efficiency of different anodes were checked. The Ti/Pt is found to be more efficient anode in treating the tannery effluent. It was found to be removing 0.802 COD/hr (NN Rao et.al. 2001)The removal of organic pollutants present in the textile industry effluent was checked using electrochemical oxidation. The COD removal efficiency was good when compared to conventional method and the treated water can also be reused for dying process in the textile industry (N.Mohan et.al 2007)Saline wastewater with organic loading was treated using Electrochemical oxidation process and the treated wastewater were found to be meeting the required criteria for reuse. The water can be reused for industrial purpose. (S.sundrapandiyan et.al 2010) The electrochemical oxidation were also investigated in the presence and absence of NaCl electrolyte. In the presence of NaCl high current efficiency was observed (Onofrio Scialdone et.al. 2009)

The different Advanced oxidation process(AOP) such as fenton, ozonation, uv photolysis, wet air oxidation were used to treat the wastewater. The AOP process have been chosen because the conventional methods could not degrade the various types of pollutants present in the wastewater. All the AOP process has employed to check the efficiency in removing the pollutants and the conclusion was that the photocatalysis is the most preferred one among all the methods (NirmalenduSekhar Mishr et.al. 2017) In a another research work carried out by Anne Heponiemi, Finland have used different AOP processes such as photolysis, UV/ozone, UV/H2O2 and UV/O3/H2O2 processes, photocatalysis. Fenton process, electro fenton process, wet oxidation, wet peroxide oxidation to treat the wastewater coming out of various industries which includes olive industry, meat processing industry, vegetable and fruit processing industry. They have concluded that the combination of AOP and biological treatment can be used to treat the industrial wastewater.(Anne Heponiemi et.al. 2012).

3.2 Electrodes used in AOP

The nature of electrodes plays a very important role in efficient pollutant removal, the electrodes such as IrO_2, graphite, Pt allows only partial oxidation of organic matters while electrodes such as Sno_2, Pbo_2, Boron doped diamond (BDD) allows complete oxidation. Among them BDD shows high removal efficiency.(Marco Panizza and Giacomo Cerisola, 2009). Ti/SnO_2 and Ti/IrO_2 were used as an electrode the composition of electrodes were most important. While using Ti/IrO_2 the primary oxidation were achieved easily when compared to Ti/SnO_2 electrodes. (Ch. Comninellis and A.NerinI).

The stainless steel and graphite has been used as cathode and anode by (Nelly Flores, Farbod Sharif et.all.2018) They have discussed the optimum voltage for the removal of tyrosol from wastewater in the presence of 2 ml of 2% NaCl as a electrolyte. The dimensions of cathode and anode are 314 plate and 3 mm thick respectively. And then the (Vanessa S et.all,2019) has used the stainless steel and boran doped diamond as cathode and anode respectively by They have discussed about the current density in this paper and conclude the optimum current density in the presence of sodium sulphate as electrolyte.The cathode and anode were iron plates and ruthenium oxide were used by (Zhihong ye, et.all.2019) The dimensions of cathode were 2.75 cm *1.5 cm* 0.25cm thickness and for anode 3 cm*3cm and the gap between the electrodes were 1.0 cm.(Francisa C. Moreira et.all,2017) has been discussed about the various types of electrochemical oxidation process. They have used boran doped diamond as a anode. They studied the five key of EOPS(electrochemical oxidation process).The cathode and anode were Ti/Pt mesh and graphite felt respectively by (AmishiPopat, P.V.Nidheesh.et.al 2019) They discussed the optimum voltage as 10V and the optimum catalyst dosage till 30 mg/l. The electrolyte were used in this process is sulphuricacid,ferrous sulphateheptahydrate and NaOH. The cathode and anode were boran doped diamond and stainless steel used by (Nizar,et.all,.2018) They discussed the current density for the electrochemical oxidation process and the dimensions of set up is 50 cm^2 and the spacing between the electrodes is 0.5 cm.The cathode and anode were platinum and boran doped diamond has been used by (Ignasi Sires, Marco Panizza,et.all,2014). The cathode and anode were $Ti/Pt.Ti/Pbo_2$,Ti/Mno_2 and Ti by (NN Rao, KM Somasekhar *et.al*,2001). The current density were used in this study is 5.66 voltage. The surface area of set up is $9cm^2$.

4. CONCLUSION

Various methods have been used to treat the wastewater produced by fish meal and processing industries. The advanced oxidation process has its own advantage like it do not produce any sludge. The AOP consumes relatively less surface area when compared to conventional methods.Among the various advanced oxidation processes the electrochemical advanced oxidation process seems to be more effective in destroying the pollutants. Since the complete oxidation take place only in this method. In process like Fenton,uv, ozonation, there is a chance of unreacted compounds turning into toxic again. While this problem will not be there in Electrochemical advanced oxidation process. So to treat the fish meal wastewater the combination of Biological and Electrochemical Advanced oxidation process methods can be adopted.

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