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A Review on Research for Industrial Wastewater Treatment with Special Emphasis on Distillery Effluent

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***Abstract*— In the era of modern civilization, the discharge of effluent from the industries is unavoidable phenomenon. Though this discharge can be reduced by process modification, it cannot be avoided. There is an urgent need for cost effective treatment method for the waste water. Distilleries and sugar industries are major part of the agricultural economy. The effluent from distilleries contains high amount of organic matter. The current paper presents the studies and investigation in industrial waste water treatment techniques. The various treatment methods were used by investigators for organic matter removal. Biological methods included aerobic and anaerobic methods. The non biological methods like electro coagulation and adsorption were also used to a great effect. There is still need to find more economical, compact and efficient treatment method for the waste water from distilleries. Future challenge lies in achieving the targets with respect to reuse of waste water in order to preserve the water reservoirs naturally available and avoid the problem of water scarcity**.

***Index Terms*—pollution, organic matter, aerobic methods, removal efficiency.**

I. INTRODUCTION

Industrial waste water from various industries is cause of concern in modern industrialization. With growing need for growth in industrial sector, there is equally urgent need to find cost effective, viable and effective alternative for waste water treatment. Sugar industries are the backbone of Indian agricultural economy. This applies for many developing countries. The distillery provides added value to this agriculture sector. The high organic loading is major factor and cause of concern for these industries. The chemical oxygen demand (COD) and biological oxygen demand (BOD) are major pollution parameters for the measure of the organic matter content. High values of COD and BOD leads to very low dissolved oxygen content. This may affect the aquatic life, which uses dissolved oxygen for respiration. There are various treatment methods used for COD and BOD removal from waste water. The conventional treatment includes physical treatment, biological treatment and chemical treatment. The challenge in this treatment lies in exploring the various alternatives, optimizing the process to achieve low cost treatment with high efficiency with compact set up and low sludge generation. The current review aims at reviewing the research and studies carried out in order to investigate new methodology for treatment, new combination of various treatment methods and comparative studies between various methods.

II. VARIOUS METHODS FOR INDUSTRIAL EFFLUNT TREATMENT

Thakkar presented the detailed chemical study of effluent of distillery waste[1]. They observed that the effluent under consideration was having very high COD and BOD and reddish colour. It also exhibited unpleasant odor of fruity smell. Because of adverse effects on man and environment, there is urgent need to treat this effluent .Rani et.al. carried out the review on biological treatment of wastewater [2]. Major pollution concern in the distillery wastewater is organic matter and colour. According to their review aerobic, anaerobic and enzymatic treatments are important part of the research carried out. It was observed that Pseudomos Fluorescens was the most effective bacteria with removal efficiency of 94 percent. It was concluded that the biological treatments are cost effective and environmental friendlily with high removal efficiency for organic matter removal. Batch and column studies for COD removal were carried out by kulkarni and goswami [3]. They treated domestic sewage by using low cost adsorbent. They found that 92-95 percent COD and BOD was removed in batch operation. For initial COD of 6000 mg/l and 60 ml/min flow rate the ideal adsorption time was 200 minutes and the exhaustion time was 300 minutes. Anaerobic Wastewater Treatment was studied with respect to Biochemical Reaction Engineering and Process Development by Aivasidis and Diamantis [4]. They provided a critical discussion on certain fundamental principles of biochemical reaction engineering relevant to the anaerobic mode of operation. They also compared single and two stages processes. According to them a volume of two stage cascade was only 3.5 percent of that required for a continuously operated stirred-tank reactor.

Khandegar and Saroh investigated removal of chemical oxygen demand (COD) from distillery effluent by electrocoagulation[5]. They conducted batch experiments with iron and aluminum electrodes. They observed that COD removal efficiency was 84.6 % and 76.9 % at initial pH (7.2),

for Al-Al and Fe-Fe electrodes respectively. Also it was found that the maximum removal was obtained at current efficiency of 17.9 mA/cm^2 in 3 hours. They concluded that electrocoagulaton technique can be successfully employed for high organic loading. Pawar studied membrane technologies for wastewater treatment. According to him proper combination of physical, biological and chemical treatment is important aspect of wastewater treatment[6]. He observed that aerobic, anaerobic biological treatments, ion exchange ,membrane technologies can be applied according to the effluent characteristics. Membrane separation techniques with immobilized microorganism or enzyme were quite attractive aspect of wastewater treatment. Three phase fluidized bed biofilm reactor was used for distillery waste treatment by biological pathway by Kumaresan et.al[7]. They fluidized calcium alginate beads by an upward cocurrent flow of gas and liquid. They used. Saccharomyces cerevisiae culture for the biological process. It was observed that the COD reduction rate increased with bed height. Same trend was observed for sludge age. With initial concentration of substrate, the COD removal decreased. Under optimum conditions, the COD reduction was 44.5 percent with 8 hors HRT(hydraulic retention time. Melamane et.al carried out research on treatment of fungally pre-treated wine distillery wastewater via anaerobic digestion[8]. $CaCO_3$ and K_2HPO_4 were used for pH buffering. They inferred that the COD removal up to 99.5 percent was possible and the system was stable to shock loading. Ansari et.al conducted a study to know the quality of effluent generated from the distillery[9]. They analyzed the parameters like colour, odor, total solids, total dissolved solids, total suspended solids, ph, electrical conductivity, total hardness, calcium, magnesium, alkalinity, chloride, dissolved oxygen, biological oxygen demand, chemical oxygen demand, ammonical nitrogen, total phosphorus, and total potassium. they found that the toxicity of effluent decreases with increase in the dilution. Anaerobic floating bed baffled wall reactor (AFBBR) was used for treatment of distillery spent wash by Lakshmikanth and Virupakshi[10]. They used activated bagasse for the treatment. They observed that the optimum COD loading rate was 2000 mg/l with maximum 68 percent COD removal. At this optimum value of COD loading, the maximum solid removal was 60 percent. For 100 ml of effluent 10 grams of adsorbent was required. They concluded that the combination of adsorption and biological method was effective alternative to explore in the treatment.

A review aimed at anaerobic membrane reactors study was carried out by Melamane et.al[11] .During the review they noted various aerobic and an aerobic methods are used effectively by various researchers effectively for wastewater treatment. According to them for evaluation of any treatment process, sufficient detail about the characteristics and concentrations of species present in the distillery wastewaters are required. They concluded that there is still need to carry out the research in this field in order to render effectiveness to the process. Saha et al. presented a case study on distillery effluent treatment[12]. They also discussed the measure for reduction in wastewater like reuse and process modification. They conducted a questionnaire survey on water use in distilleries neat Delhi. They found that the anaerobic treatment was a part of primary treatment, sometimes followed by secondary treatment. They concluded that there is still scope for improving the waste water treatment methods. The house keeping and maintenance of the treat plants played important role in the efficiency of the treatment. Bama et.al carried out research to find the optimal dilution factor of the effluent before discharge through construction of wet lands[13]. They fist diluted the effluent 5,4,3,2 and 1 times with ground water which was ineffective. So they used dilution ratios of 5, 10 and 20 to facilitate the plant growth. The optimum dilution factor was 20 at which plant survived because of the pH value achieved . The aerobic mechanism was used for further reduction. The overall effective of this treatment was combination i.e. aerobic and anaerobic. For this ,at pH of 6 optimum dilution ratio was 5. Treatment of distilleries and breweries spent wash wastewater was studied Ayub and Usmani[14]. Their review indicated that the parameters like pH, adsorbent dose, and initial concentration were important parameters in the wastewater treatment by adsorption and biosorption. According to them activated carbon was most effective adsorbent. For, 200 ml of effluent , 10 grams of adsorbent and 24 hours contact time was required. During the investigation, maximum removal of 93 percent was observed by them. Ayub and Usmani presented a case study on pollutants removal from distilleries and breweries spent wash in Aligarh(Uttar Pradesh, India)[15]. They used natural adsorbent for the treatment of waste water. They observed that there was certain limit for increasing the adsorbent doses for given amount of effluent. An excess use can leads to uneconomical process. According to them, the initial concentration also plays an important role throughout the adsorption . Lekshmi explored the use of anaerobic digestion as complete solution to treat BOD and COD[16]. She used hydrogen peroxide oxidation between two anaerobic reactors. About 21 percent COD was removed in first stage. Overall removal efficiency was about 90 percent. This means the COD's biodegradability was increased by using by hydrogen peroxide oxidation.

Novel microbial consortium was used by Pal and Vimala for Bioremediation and decolorization of Distillery effluent[17]. Pseudomonas aeruginosa and Aspergillus niger in combination gave far better results than used alone. COD reduction of 60 percent was achieved in 15 days. Hampannavar et.al treated distillery waste using microbial fuel cell(FC)[18]. The investigation was carried out at ambient temperature. They compared double chambered FC with single chambered FC. They observed that double chambered FC was more efficient in COD removal than single chambered FC with the removal efficiencies of 64 and 61 percent respectively. They attributed COD removal observed in distillery wastewater to microbial catalyzed electrochemical reactions occurring in the anodic chamber. They concluded that single chamber was better alternative with only 3 percent compromise on efficiency but very significant reduction in cost and mentainace. Membrane

bioreactor technology utilizing pseudomonas fluorescens was used for effective treatment of distillery waste by Manyuchi and Ketiwa[19]. During the investigation 99.2 percentage of increase in the pH was observed . They also observed that the BOD removal was 96 percent and COD decreased by 98 percent. They concluded that the membrane technology was effective method with about 95 percent removal of pollutants. Bhardwaj and Bhasin carried out case study for adoption of mathematical approach to assess phytoremediation potential of water hyacinth for distillery effluent[20]. The parameters like pH, BOD, COD, TSS, TDS, Na and K showed exponential decrease from the start up to 45 days and thereafter showed negligible decrease. The model predicated trend of phytoremediation potential of water hyacinth for distillery effluent. They concluded that similar models can be developed for other industrial effluents also.

Rajvanshi and Nimbkar treated the distillery waste by using solar detoxification[21]. They used continuous anaerobic reactor for the purpose. They used of TiO_2 as a photocatalyst for treatment. They developed two step process consisting of pretreatment and solar detoxification (SD) .An average COD reduction of about 95-98% and average increase in transmittance (%T) of about 85-90% was observed during the investigation. TIO_2 along with coagulant gave better results. They also observed that about 90 percent catalyst can be recovered. Effect of dilution of treated distillery effluent (TDE) on soil properties and yield of sugarcane was studied by Sivaloganathan et.al[22]. Dilutions of 1:10, 1:20, 1:30, 1:40 and 1:50 were carried out. The dilution factor of 1:10, according to their study gave higher crop yields. The quality parameters of sugarcane were unaffected by TDE factor. Biodijester effluent was treated electrochemically by Vijaya et.al[23]. They found the optimum time at which maximum COD removal takes place using aluminum as electrode. The optimum time interval of 120 minutes and the optimum COD removal efficiency was 60.6 percent. It was observed that with increase in current density , the removal percentage increased. Tripathi et.al conducted a mini review on fungal treatment on industrial waste[24]. According to the study, the rot algae, because of their availability in extreme conditions are good biodegraders. They have been used successfully in various investigations for the waste water treatment. Ince et. al reviewed Microbial ecology of anaerobic reactors for treatment of alcohol industry wastewaters[25]. Variety of grains, fruits and vegetables used as raw materials in alcoholic beverage production impart assorted characteristics of wastewaters. Up flow anaerobic, anaerobic sequencing batch biofilm reactor (ASBBR) fluidized bed (FB) reactor, expanded granular sludge bed (EGSB) reactor, up flow fixed film column (UFFC) are few important types of contactors used for the treatment. They concluded that there is need for presence of diverse population of microorganisms to achieve a stable and efficient reactor performance. The adsorbent prepared from coconut coir was used by Kulkarni for COD and BOD removal from domestic effluent[26]. He obtained about 80 percent removal in COD and BOD. The optimum parameters were 2 grams/100 ml of adsorbent , pH of 6 and contact time of 90 minutes.

III. CONCLUSION

It was observed during the review that there are many alternatives available in biological processes, both aerobic and anaerobic. The non biological methods mainly include adsorption, electrocoagulations and membrane filtration. Combination of these method also can be used for more effective results. The type of method used for the treatment depends on the effluent characteristics and biodegradability. Many investigators have achieved the objective of optimizing various affective parameters for the processes they used. There is still scope for research in order to further reduce the cost and land requirement. The future challenge lies in reuse of maximum industrial waste water and reducing the need of fresh water from the reservoirs to avoid further scarcity of water in many parts of the world.

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