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A REVIEW ON ANAEROBIC TREATMENT FOR WASTEWATER:APPLICATION, METHOD AND RESULTS

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ABSTRACT
Chemical oxygen demand (COD) indicates the amount of organic matter present in the wastewater. This organic matter depletes the dissolve oxygen (DO) content. Also presence of other pollutants like suspended solids, phosphorous, metals etc. is not desirable in the wastewater. Biological treatments are economical and effective for organic matter removal. Anaerobic mode of biological treatment is very effective for treating domestic and industrial sludge containing high organic loading. Various investigators have investigated the anaerobic treatment methods with respect to affecting parameters, removal efficiency and economy. The current review summarizes studies and research on anaerobic wastewater treatment.

INTRODUCTION
Wastewater treatment plants comprises of primary, secondary and tertiary treatments. Physical, biological and chemical treatments are carried out as per requirement and effluent quality. The effluent from industries contains high organic matter content. It also contains various toxic and hazardous materials. It also may contain metals. The domestic effluent is very high in organic loading. The organic matter present is measured in terms of chemical oxygen demand (COD) and biological oxygen demand (BOD). The presence of dissolved oxygen is also important quality parameter for water. Removal of organic matter from wastewater can be carried out by various biological and non-biological methods. The biological treatment includes aerobic and anaerobic treatment. Activated sludge process and trickling filters are used for biological treatment [1,2,3,4,5]. Adsorption by using low cost adsorbents is also very economical and effective treatment method[6,7,8,9,10]. The anaerobic treatment of wastewater has advantages such as cost, area and biogas generation. The current review summarizes research carried out on anaerobic treatment of wastewater.

REVIEW ON ANAEROBIC WASTEWATER TREATMENT
Lew et.al. carried out studies on an upflow anaerobic sludge blanket (UASB) reactor for domestic wastewater treatment at low temperatures[11]. They carried out comparative studies between a classical UASB and hybrid UASB-filter reactor. They found that the COD removal resulted from biological degradation and solids accumulation in the reactors. At low temperatures, solid accumulation played major part in the treatment. At 28^{O}C and higher temperatures, COD removal was attributed to biological degradation only. They observed that the decrease in biological degradation at lower temperatures was offset by solids accumulation. They concluded that the classical UASB reactor and the hybrid UASB-filter reactor can be a good alternative for domestic wastewater treatment.Sunny and Mathai carried out investigation on treatment of fish wastewater[12].The environmental problems because of fish wastewater arises because of high water consumption and high organic matter, oil and grease, ammonia and salt content in their wastewaters. They found that system ammonia content, wastewater salinity, oil and grease play a decisive role in the efficiency of fish processing wastewater treatment. According to them, anaerobic treatment processes are most widely used for treating wastewaters but these processes partly degrade wastewater containing fats and nutrients. They concluded that an integrated design using physicochemical process followed by biological process would yield better treatment efficiency with less energy consumption and reduced sludge production. Review on the suitability and the status of development of anaerobic reactors for the digestion of selected organic effluents from sugar and distillery, pulp and paper, slaughterhouse and dairy units was carried out by Saleh and Mahmood[13].They found that an anaerobic contact reactor can be used without pre-treatment for slaughterhouse wastewater. For high rate

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UASB, a pre-treatment step for removal of the suspended solids and fats is essential prior to anaerobic treatment. In case of pulp and paper industry, due to variation in effluent quality, it is better to treat the effluent in separate sections. They concluded that UASB and fixed film configurations are the most suitable for effluent treatment. Gasparikova et.al. carried out investigation on seven small wastewater treatment plants for evaluation of anaerobic-aerobic wastewater treatment[14].They studied an integrated system originated from the combination of anaerobic and aerobic technologies. According to their investigations, the properly operated two-stage technology is effective for the removal of organic pollution and suspended solids. They also observed that the fluctuation of the wastewater flow can also be a perturbing influence.

Ahmed et.al. carried out an investigation on combined anaerobic-aerobic system for treatment of textile wastewater[15]. The textile industry wastewater is rated as the most polluting among all industrial sectors. They operated a combined anaerobic-aerobic reactor continuously for treatment of textile wastewater. They used cosmo balls as media for microorganisms in anaerobic reactor. They investigated effect of pH, dissolved oxygen and organic changes in nitrification and denitrification process. They concluded that the combined anaerobic-aerobic system was able to treat high strength textile wastewater. They obtained maximum removal of the maximum removal of ammonia nitrogen, BOD,COD, VSS as 84.62%, 63.64%, 60% and 98.9% respectively. Aiyuk et.al. carried out studies on domestic wastewater treatment without pre-treatment[16]. They assessed the performance and stability of a domestic sewage treatment system consisting of an upflow anaerobic sludge blanket (UASB) reactor. For initial COD of 522 mg/l, the system could remove 80 % of the organic matter. They found that, up to 70 % of influent chemical oxygen demand is found as suspended solid. Repeated sludge discharges from the reactor were necessary. They also observed that perturbations of the macrobiotic arose following the sludge extractions. Tokutomi studied new aerobic and anaerobic wastewater treatment process[17]. According to these studies, aerobic treatment can reduce over 70% of the excess sludge. He found that the anaerobic treatment with fluidized carrier material can expand the application field of anaerobic treatment. Biogas generation is additional advantage of the anaerobic treatment.

Microbial dynamics during anaerobic digestion of cow dung was studied by Christy et.al.[18].They carried out 30 days run in laboratory reactor. They observed that hydrolytic bacterial population was initially increased and decreased towards the end of anaerobic digestion. They also found that the population, during methanogenesis was initially very low and increased gradually towards the end of anaerobic digestion. They observed maximum methane yield of about 64% at 30th day of digestion. Gonzalo et.al. carried out studies on anaerobic treatment of phenol[19]. They carried out experimentation in a continuous fluidized-bed bioreactor. They treated a mixture concentration of 500 ppm organic acids a 600 ppm of phenol. Considering first order kinetics, they obtained the kinetic constant of phenol degradation of 0.0012 L/mg·day. Britton et.al. carried out research on the removal of phosphorous by using anaerobic mechanism[20].They demonstrated the ability of the reactor to remove at least 70% of the phosphate in the supernatant from a digester fed with a combination of primary and secondary sludge. They achieved phosphorous removal upto 90 percent in the treatment. They determined the operational parameters which governs the operation of the pilot-scale reactors treating real anaerobic digester supernatant from a full-scale enhanced biological phosphorus removal. They found that pH was one of the important parameters in the treatment.

Combined anaerobic digestion and biological nitrogen removal for piggery wastewater treatment was carried out by Rousseau et.al.[21]. They developed a piggery wastewater treatment process consisting of combined anaerobic digestion and biological nitrogen removal by activated sludge. They also presented a modeling framework in order to optimize this process. They developed interfaces which allowed model coupling with maintenance of COD, Nitrogen, alkalinity and charge balances. Chang reviewed anaerobic membrane bioreactors (AnMBR) for wastewater treatment [22]. His review focused on the recent research in the development of anaerobic membrane bioreactors in wastewater treatment. According to him, recent development in the large-scale wastewater treatment MBR has largely increased the potential of the anaerobic membrane technology as a practical, advanced full-scale wastewater treatment technology. A review on the suitability and the status of development of anaerobic reactors for the digestion of selected organic effluents from sugar and distillery, pulp and paper, slaughterhouse and dairy units was carried out by Rajeshwari et.al.[23]. According to them, there exist certain differences in the preference of a particular type of digester over others in terms of various factors such as requirement of pre-treatment, dilution, control of operating conditions, etc. They observed that an anaerobic contact reactor can be used without pre-treatment whereas for the usage of high rate digester such as UASB for slaughterhouse wastewater. For distillery effluent, UASB and fixed film reactors are more commonly used. For pulp and paper industry effluent, it is necessary to carry out the treatment in separate sections due to variations in effluent quality. Hemalatha et.al. investigated the stability of hybrid up flow anaerobic sludge blanket (HUASB) reactor for various parameters like pH, total suspended

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solids and COD removal [24]. They used a specific packing media of polypropylene polyhedral spherical balls. They observed that the biomass attachment and accumulation was predominant over the surface of the polypropylene polyhedral spherical balls. Mittal discussed the differences between aerobic and anaerobic biological treatment processes[25]. According to him, economic advantage, both in terms of capital investment and operating costs, of biological treatment makes them better choice over other treatment processes like chemical oxidation; thermal oxidation etc.

Lebrato et.al. carried out an investigation on cheese factory wastewater treatment by anaerobic semicontinuous digestion[26].They used six thermostatically-controlled digesters in a bath at $35^{O}C$ which were magnetically stirred at 100 rpm.They observed that minimum retention time required was 9 days. Also they found that the efficiency of treatment varied between 90 and 78 percent. Pharmaceutical wastewater treatment was carried out by Chelliapan and Sallis by using anaerobic biotechnology [27]. According to him, due to high strength, it is infeasible to treat some pharmaceutical wastewater using aerobic biological processes. They presented literature on anaerobic digestion, anaerobic reactor technology and existing anaerobic treatment of pharmaceutical wastewater. They treated pharmaceutical wastewater containing the antibiotic Tylosin in an anaerobic reactor. They obtained 70-80 percent reduction in chemical oxygen demand (COD) during the treatment. They obtained an average of 95% Tylosin reduction in the treatment. Hampannavar and Shivayogimath used upflow anaerobic sludge blanket reactor at ambient temperature for anaerobic treatment of sugar industry wastewater[28].They achieved successful reactor startup with granulation within 95 days of operation. They found that optimum hydraulic retention time, HRT was 6 hours. They also observed that methane content in the biogas was between 73 and 82% at steady state conditions. They concluded that sugar industry wastewater can be treated at maximum loading of 16 g COD/L.d. at low HRT of 6 at ambient temperature. Tamilchelvan and Dhinakaran treated tannery waste water by anaerobic digestion treatment[29].They observed that tannery waste water has anaerobic biodegradability at the suitable COD. They observed a considerable rate of decrease in the values of COD, BOD, chromium, pH, and acidity. Biogas generation is additional advantage of this treatment method. Dwaraka and JayaRaju carried out an investigation on municipal wastewater treatment and kinetic studies using immobilized fixed bed anaerobic digester[30]. They performed a series of three independent batch experiments. A mixed sludge collected from dock yard was used as the source of waste generation. For influent COD concentration of 226mg/L, 85 percentage COD removal was achieved by them.

Visvanathan and Abeynayaka carried out a review aimed at a basic description of the anaerobic wastewater treatment process[31]. They also summarized work on anaerobic membrane bioreactors (AnMBRs) with emphasis on recent trends. According to them, the AnMBR performances have achieved comparable status to other high rate anaerobic reactors. According to Appels et. al., anaerobic digestion plays an important role for its abilities to further transform organic matter into biogas (60–70 vol% of methane)[32]. They observed that hydrolysis was a rate determining step in the complex digestion process. The anaerobic digestion is affected by factors such as pH, alkalinity, and concentration of free ammonia, hydrogen, sodium, potassium, heavy metals, volatile fatty acids and others.

I. CONCLUSION

The classical UASB reactor and the hybrid UASB-filter reactor can be a good alternative for domestic wastewater treatment. Anaerobic treatment processes are most widely used for treating wastewaters but these processes partly degrade wastewater containing fats and nutrients. Biological degradation at lower temperatures was offset by solids accumulation. An anaerobic contact reactor can be used without pre-treatment for slaughterhouse wastewater. In case of pulp and paper industry, due to variation in effluent quality, it is better to treat the effluent in separate sections. Tannery waste water also has anaerobic biodegradability. Effluent from other industries like sugar, pharmaceutical, milk and cheese factory etc. can also be treated effectively by using anaerobic treatment method.

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