A review on different methods of dairy wastewater treatment

[1]A. S. Tompe, [2] C.H. Wagh.

[1] M. Tech. Student, Civil-Environmental Engineering, Walchand College of Engineering, Sangli, Maharashtra, India, 416-415.
[2] Associate Professor, Department of Civil Engineering, Walchand College of Sangli, Maharashtra, India, 416-415.
[1]atmatompe96@gmail.com [2] chandrakant.wagh@walchandsangli.ac.in

Abstract*— One of the major sound ways of saving water is treatment of wastewater from different industries and its reuse. Out of that Dairy industry is major wastewater generator and water consumer as well. The dairy industry involve the processing of raw milk into various products like milk and milk powder, butter, cheese, ghee, yogurt etc. by using processes pasteurization, packaging filing in cans which enhances the life of dairy products. Characterization of dairy waste stream is done with high concentrations of suspended solids, high biological oxygen demand (BOD) and chemical oxygen demand (COD), high nitrogen concentrations, high suspended oil and grease contents, and large variations in pH which requires special and concrete method of treatment. Generation of dairy wastewater is 1 to 3 times the volume of milk processed so to promote sustainability reuse of dairy wastewater is necessary after the proper way of treatment. The conventional methods were used to treat dairy wastewater such as Physico-chemical and biological treatment but widely biological treatment are used which are aerobic and anaerobic treatment. Conventional methods are proven to be less effective than the advanced methods because of high area requirement, problem of high maintenance cost, labor cost and also disposal problem of sludge. The present paper is a review on the several methods and their performance evaluation comparison of dairy wastewater on the basis of evaluated parameters. Primary objective of this study is to find out more effective way of treatment using comparison.

Index Terms—*Dairy wastewater, Conventional method, advanced method, BOD and COD.*

I. INTRODUCTION

Unscientific and Improperly treated or untreated industrial wastewater disposals lead to environmental pollution. Rising population technological, economical and industrial revolution and changing life style has led to various types of environmental problems, water pollution, land pollution, Air pollution, nuclear pollution; sound pollution including spiritual pollution are the aspects of pollution today. Several new technologies for modernity and change in life style of humans attribute new industries for their easiness and comfort ability on one side which results in highly complicated and dangerous waste generation on the other side. Out of which, water pollution due to wastewater is most concerned with civil engineering. Therefore wastewater treatment of domestics and industrial sources is very important aspect of civil engineering.

Rapid growth of industries has not only enhanced the productivity but also resulted in the production and release of toxic substances into the environment, creating health hazards and affected on normal operations. The dairy industry is one of those sectors of industry producing huge amount of wastewater of strong pollutant potential. As the rapid industrialization taking place all over the country, the number of dairy industries is sharply rising. So it's necessary to give effective treatment before its discharging anywhere. Because the dairy industry is a major user of water and generator of wastewater, it is necessary for wastewater reuse.

Dairy effluent streams are highly organic in nature so when dairy wastewater directly discharged into river or stream then deficiency in oxygen level may get occur. Dairy wastewater have highly pungent odor and that is biologically active. Majority of waste water released from dairy industry is from cleaning operations like cleaning of silos, homogenizers, tanks, pipe sand, heat exchangers and other equipment and it contains high organic load. The dairy waste streams are also characterized by wide fluctuations in flow rates, which are related to discontinuity in the production cycles of the different products. All these aspects work to increase the complexity of wastewater and its treatment. In present review paper attempt has been made to review on several methods of dairy wastewater treatment and to find out more effective way of treatment using comparison amongst them.

II. LITERATURE SURVEY

A. Using Electrocoagulation Process

One of the most advanced techniques for pollutant removal from raw waters and wastewaters is Electro-coagulation (EC). Minimization of power supply necessity and reduction in electricity requirements are two major causes due to which electrocoagulation become affordable for wastewater treatment. **(Deepak Sharma 2014)** Removal efficiency of COD and oil, grease is found to be 98% and 99% respectively. For an operating time of 1 min, optimal current density was 0.6mA/cm^2. Electrode consumption throughout the operation is 0.0204 g electrode/ kg COD removed whereas at the optimal conditions the power requirements were 0.003 kWh/kg COD. **(Ayhan S¸ engiland Malmutozacar 2006)** Further EC process was successfully

applied to the Dairy wastewater and more observations were made that the turbidity removal was dependent on supplied voltage and the concluded that as voltage increases then the turbidity removal also increases. Initial pH, applied voltage and operating time are three parameters on which the removal efficiencies of turbidity and COD are dependent. **(Gouri Mirjiand and Dr.P.B.Kalburgi 2014)** In another study Mono-polar parallel connection system was used to remove the color and BOD, COD and total solids, turbidity as well and the treated effluent looked like water because color removal was observed 100%.In this system maximum COD, BOD, total solids and turbidity removals were 88%, 88.98%, 63.5% and 93.1% respectively. The parallel conclusion for EC technology is that aluminum electrodes in mono-polar parallel system are efficient and economical for dairy waste water treatment**. (C. B. Jagadal et al 2017)**

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B. Using Reverse Osmosis (RO) and Nano Filtration (NF)

The studied RO and NF membranes can be used for concentration of dairy effluents at low pressure. The higher permeate quality was found with RO membranes. As NF did not provide a better permeate flux, RO operation gave better water quality than NF.The fouling indexes indicated the fouling factor that was higher for RO.The RO successfully generated a high quality permeate suitable for re-use. The higher permeate quality was observed with RO membranes which showed better rejection of milk components. **(Ivanna Kyrychuk et al 2014)** For average permeate flux around 11 L RO treatment of the dairy wastewaters was carried out until 90–95% water recovery was achieved. Scale-up was proposed for the treatment of 100 m^3 per day wastewater in which a plant of 540 m^2 RO membrane area permits the recovery of 95%. Allowing treated dairy wastewater to be reused for heating, cleaning and cooling purposes.**(Mickael Vourch et al 2007)** The high quality of the MBR permeate also allows water reuse in some applications (non-potable), without the need for the additional RO, UV and chlorination steps. The biological performance of the MBR was excellent, with high rates of both COD and nitrogen removal demonstrated. This was achieved or exceeded, as long as a recovery rate of 50% or less was applied in the single pass RO membrane. The quality of the MBR permeate was suitable for direct treatment in the RO plant. The results indicate a full-scale single pass RO plant could operate with 50% recovery, or 70% recovery with a two-pass RO system.To produce water with greater recovery, and retain potable quality, a two-pass RO system should be employed **(B. Chapman et al 2011)**

C. Using Natural Coagulants

In addition to preliminary treatment, Dairy wastewater treatment units are observed to follow the biological treatment methods. Removal efficiency for COD of dairy effluent stream was found to be 25% during preliminary treatment such as screening, oil and grease removal and aeration.

It is observed that *Cicerarietinum* is more effective than other natural coagulants such as *T.foenum-graecum, M.oleifera* and *D.lablab*. Among the three natural coagulants, the maximum reduction of turbidity and COD is found to be 78.33% and 83% with *Cicerarietinum* which are higher reductions with others. **(Prof. Chidanand Patil and Ms. Manika Hugar 2015).** The COD reduction varies from 15.47 to 63.49% and optimum reduction of 63.49 percent was observed at *Moringaoleifera* dose from 60 to 65 mg/L. it can be concluded that wastewater COD of 1680 mg/L can be reduced to 460 mg/L i.e. 72.61 percent through preliminary treatment + coagulation with *Moringaoleifera* coagulant. *Moringaoleifera* is tropical plant, which is resistant to adverse environmental conditions, can be grown on the dairy wastewater if disposed off on land for irrigation. **(D. S. Bhutada et al 2006).** It clearly shows that natural coagulant like *moringaoliefera* reduce the value of pH of 7.4-7.1 and removes turbidity-68.985%, TDS69.73%, COD-52.38%, BOD-85.28%, respectively. From the comparative studies we have concluded that the chemical coagulant like alum is more superior to natural coagulant. **(Chaitali Bangar et al 2017).** The reduction of turbidity is 78.49%, reduction in BOD_3 is 79.64%, reduction in COD is 85.81%, reduction in total dissolved solids is 8.59% and reduction in total suspended solids is 95.45%. Hence the *Moringa Oleifera* as a natural coagulant is effective for treatment of dairy wastewater, and the treated diary waste water can be used for irrigational purposes. Comparing the result with *Phaseolus vulgaris* as natural coagulant, the *MoringaOleifera* gives a better result. **(Neethu. P et al 2017).** Regarding the removal of COD, it appears that for *Tanfloc SG* coagulant, COD removal was 77.28 %, and for *Tanfloc SH* was 44.14 %. The treated effluent with *Tanfloc SH* also has potential for reuse in toilets discharges. **(Gabriele Wolf et al 2015).**

D. Using Upflow Anaerobic Sludge Blanket

After the treatment using Up-Flow Anaerobic Sludge Blanket Reactor (UASBR) Dairy waste water can be used for agriculture or cleaning purpose and the formed methane (CH_4) can be used as an energy source. The UASBR process is seen as one of the most cost effective & efficient anaerobic treatment on the basis of review on results. **(Prof. P. A. Shirule et al 2013).** In further study the maximum COD removal efficiency was 78%. The percentage removal of sulphate ranges 45-50% also it is found that with increase in HRT sulphate removal increases and amount of gas collection as well. Conclusion is that the UASB reactor is suitable method to treat the dairy wastewater. From the reactor biogas generated was 350ml when it was operated for 43 days. **(R. Thenmozhi and R. N. Uma 2012)** One more study was carried out in between removal efficiency and HRT. The maximum digester COD removal efficiency of 98% was reached at an HRT of 6 days with an influent COD concentration of 37 g/ l (OLR"62 g COD/ l d). When increasing the influent COD concentration to 42 g/l (OLR"75 g COD/ l d), the COD removal was reduced to 85.90% with a mean COD effluent concentration of 5 g/ l. **(H. N. Gavala et al 1998)** The main conclusion drawn from another study is UASBR design is feasible to treat dairy industry wastewater efficiently. In this case the maximum COD removal efficiency was 80%; maximum flow rate obtained in the reactor was 10000 L/d and maximum BOD_5 removal in OLR=7.6 kg/ (m^3.d) was 90%. **(Farhikhteh Samadi et al 2017).**

E. Using Constructed Wetland

Constructed wetlands have been gaining popularity for treatment of wastewaters of high potential. Constructed

wetlands are relatively inexpensive and easy to construct and maintain. Following some reviews on papers discuss the performance of constructed wetland for the treatment of dairy wastewater.

Growth of water hyacinth plant is dependent on organic strength of wastewater. If COD values are higher than 2,380 mg/L then it is significantly affected. Water hyacinth system is efficient to an extent of 70 to 80% for low strength dairy wastewater (COD, 1,672mg/L). Further Water hyacinth does not remove TDS but has a potential to reduce organic strength of wastewater from small-scale dairy. They alone contribute 30% to 45% in removal of COD and tend to neutralize the pH of wastewater. **(G. R. Munavalli and P. S. Saler 2009).** In another study it is proven that constructed wetlands are as a best management to treat wastewater from dairy. Ammonia (NH_3) is a major constituent of dairy wastewater and found in concentrations as high as 220 mg NH_3-N/lit. Ammonia loading from dairy lagoons to streams was reduced by 97% after wetlands were constructed to receive the lagoon effluent. On a dairy farm in Sonoma County, California, it is observed that wetlands alone have successfully reduced BOD_5 (97%), TSS (99%), TKN (96%), NH_3 (86%), and TP (93%). **(Julie K. Cronk 1995).** One more study was carried out regarding to remove BOD and COD using artificial wetland. In the Constructed Wetland treatment process of dairy wastewater, pH was brought up much near to the neutral axis due to the techniques implemented and removal efficiency of BOD is 85-90%, and COD is 75-80%. **(Pachpute A. A et al 2014).**

CONCLUSION

For looking dairy effluent like water it should be treated with mono-polar parallel connection system using electrocoagulation as Aluminium electrodes are proven to be most economical and efficient in the electrocoagulation process. Water recovery achieved using RO treatment is also higher thereby RO is better treatment than NF for dairy wastewater effluent streams for reuse purpose. For coagulation process *Cicerarietinum* is proven to be a best natural coagulant as compared other natural coagulants. *Tanfloc SH* has also potential to make dairy wastewater for any reuse purpose. Treated wastewater using UASBR has more COD than treated with any other methods whereas biogas production is an advantage of UASBR. Reduction in BOD and COD are observed more in constructed (artificial) wetland method than other methods of treatment. Simultaneously constructed (artificial) wetlands have benefits of low cost and less manpower as well.

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