

Review on Aeration: Studies and Investigations Across Various Applications

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ABSTRACT

Various biological treatment methods include aerobic and anaerobic methods. Aerobic methods include advanced oxidation methods, aerobic digestion methods. Anaerobic methods for treatment of wastewater include anaerobic digestion. Anaerobic digestion of wastewater has advantage of additional value added product, biogas. Aeration is one of the important aspects of biological treatment methods. Modification of basic method includes tapered aeration, diffused aeration, deep shaft aeration etc. Various investigators have studied aeration and its advantages. Also applications of aeration in some specific applications like oil aeration, aeration of boiled sweets, aerated lightweight concrete also are investigated by various researchers. Current review summarizes research and studies on aeration.

Key words: Diffuser, oil aeration, accuracy, stability, concentration.

INTRODUCTION

Biological wastewater treatment processes are classified as suspended and attached growth methods. In suspended growth methods, activated sludge process and aeration techniques are important aspects of operations. Activated sludge process is most widely used method for wastewater treatment. [1-5] Attached growth methods are important because of their ability to handle high concentrations of organic material depending on the type of media used. [6-10]

Various biological treatment methods include aerobic and anaerobic methods. Aerobic methods include advanced oxidation methods, aerobic digestion methods. [11-14] Anaerobic methods for treatment of wastewater include anaerobic digestion. [15-17] Anaerobic digestion of wastewater has advantage of additional value added product, biogas. The biogas can be used for domestic fuel requirements. Other treatment methods

include membrane separation, pervaporation, solar distillation and other advanced treatment techniques. [18-21]

Aeration is one of the important aspects of biological treatment methods. Modification of basic method includes tapered aeration, diffused aeration, deep shaft aeration etc. Various investigators have studied aeration and its advantages. Also applications of aeration in some specific applications also are investigated by various researchers. Current review summarizes research and studies on aeration.

REVIEW ON AERATION: STUDIES AND INVESTIGATIONS

Said et.al. investigated effect of forced aeration and initial moisture content on red pigment. [22] They also studied effect of aeration on biomass production by *Monascus ruber* in packed bed solid state fermentation. They studied effects of various factors such as aeration rates, initial moisture level on colour production. They

carried our packed bed solid state fermentation at a nominal temperature of 30 °C. Goodwin et.al. carried out investigation on the effect of oil aeration on the load-carrying capacity of a hydrodynamic journal bearing. [23] In their work they verified the assumption that presence of air bubbles in the lubricating oil of a hydrodynamic bearing gives rise to a reduced load-carrying capacity. In their work, they also provided quantitative data relating to the concentration of air bubbles and their size that are required for any discernible effect. They observed a slight decrease in bearing load-carrying capacity at high operating speed after aeration of lubricating oil.

Bell and Abel studied WWTP aeration process upgrades for energy efficiency. [24] Their investigation was focused on optimization of the process. According to them, process upgrading steps can give additional savings. This can save considerable power as 60 percent of the power consumption is due to aeration. Chanson et.al. investigated self-aeration along the chute and by flow aeration in the hydraulic jump at the downstream end of hydraulic structure such as weirs, spillways. [25] They analyzed experimental data and compared it with a numerical method to predict the free-surface aeration. They also compared aeration during hydraulic jump and compared it with numerical correlations. The investigation indicated that for smaller water discharges, self-aeration might contribute to a large part of the oxygenation taking place at hydraulic structures. Trillo and Smith studied online off gas analysis system for process and aeration optimization. [26] They explained few examples of utilization of online Off Gas data. Proper utilization of this data helps to reduce the aeration requirements and also improve accuracy and stability of aeration control. Candy carried out studies on aeration of boiled sweets. [27] Suspension of gas bubbles within an amorphous sugar glass is termed as aeration of boiled sweets. In his studies, he explored the available methods of achieving this suspension of gas

bubbles within the amorphous sugar glass. Aeration of boiled sweets provides a glossy, satin-like appearance and a crispy or crunchy finished product structure. The density of cooking mass reduces due to aeration. High viscosity masses need more energy masses. Pigue studied changes in dissolved oxygen, ammonia, and nitrate levels in an extended aeration wastewater treatment facility. [28] He observed these variations while converting from counter current to disc diffuser aeration. He found that dissolved oxygen levels were significantly higher after conversion. He also observed that ammonia levels were significantly higher for single basin than for dual basin.

Detailed studies on aerated lightweight concrete were carried out by Hamad. [29] Aerated concrete, according to him, has advantages such as strength to weight ratio, lower coefficient of thermal expansion, and good sound insulation. The aerated light weight concrete can be classified as foamed concrete and autoclaved concrete. According to these studies, low densities with higher strength compared with conventional concrete are major advantages of the aerated concrete.

Casey carried out studies on diffused aeration system for activated sludge process. [30] Aeration serves purpose of mixing along with oxygen transfer. According to him, clear that careful attention to aeration system design, including blower selection, can yield a significant energy/cost saving. According to him, Fine bubble diffused air systems are better than commercial diffusers. The wastewater contaminants adversely affect the oxygen transfer efficiency of diffused air systems. Flexible membrane diffusers are likely to lead to a greater use of fine bubble diffused air systems at small to medium sized wastewater treatment plants. El-Rahim et.al. carried out studies on textile dye bioremoval by *Aspergillus niger*. [31] Their emphasis was on effect of aeration. They carried out experiments with the bioremoval/biosorption of dis-azo dye by *Aspergillus*

niger strain 20 in two concentrations. They compared their results a various operating conditions. In their studies, they found that fungal biomass obtained at the three other air flow rates was more or less the same after 3 days of incubation. Compared to high aeration rates, lower air flow rates showed higher bioremoval.

Sundberg studied the parameters like aeration, temperature and pH for improving composting efficiency. [32] In his work he tried to develop methods to improve process efficiency in large-scale composting. He investigated acid-related process inhibition. In his study, he observed that temperature above 40°C and pH below 6 severely inhibits the composting process. He found that increasing the aeration rate can have positive effect on the activity. It also shortens the acidic phase. He also developed a dynamic model for the initial self-heating phase of batch composting. Anandraj investigated self-aeration characteristic of hydraulic jump. [33] According to him, cost effective and trouble free oxygen transfer can be achieved by using hydraulic jump compared to conventional methods. Aeration efficiency and energy loss along the jump have positive relationship between them. He expressed need for vast number of experiments for studying influencing parameters.

Mocanu and Mihailescu carried out studies on aeration processes for waste water treatment. [34] They expressed need for better and modern aeration facilities. According to them, maintaining enough oxygen level and activity of sludge are two important aspects of efficient aeration. Åmand et.al. carried out studies on aeration control. [35] They reviewed various methods of automatic aeration control systems. They also reviewed various methods for D.O. determination and strategies. Bhuyar et.al. carried out an investigation on aeration efficiency and overall oxygen transfer coefficient for aeration through curved blade aerator. [36] In their work, they designed a high efficiency curved-blade-surface mechanical aerator. They studied

dynamic parameters such as diameter of aerators (D), speed (N) and immersion depth (h). They also developed a CFD model. This CFD model helped in better understanding of the process that takes place inside the ditch.

Amenaghawon et.al. carried out studies on impact of nutrients, aeration and agitation on the bioremediation. [37] They studied bioremediation of crude oil polluted water using mixed microbial culture. The air supply had positive effect on the remediation medium. They concluded that aeration and agitation during nutrient supplementation can have positive effect on bioremediation. Subramani and Arulalan carried out investigation on surface aerator in the activated sludge process treatment. [38] They studied activated sludge plant in food processing. They observed reduction in the values of COD and BOD due to aeration. Baylar and Bagatur carried out investigation on aeration efficiency at weirs. [39] According to them, the reason for the accelerated transfer of oxygen is entrainment of air in the flow which produces bubbles. According to them, air bubbles greatly increase the surface area available for mass transfer. They also observed that the aeration efficiency of the triangular notch weir is generally better than the other weirs.

Mackay et.al. in their work, evaluated aeration efficiency of two types of aeration devices, namely air injection and mechanical surface aerators. [40] For air injection system, they tried different diffusers, namely open-ended tubing, linear fine bubble diffusers and a membrane diffuser. Solpico et.al. investigated dissolved oxygen, conductivity and temperature in the lake at two depths. [41] They observed that LED flood lamp at night enhances the aerator performance. According to their hypothesis, phytoplankton react to the LED light and begin photosynthesis. This adds oxygen concentration in the water. Sotirakou et.al. investigated extended aeration ammonia and phosphorus removal. [42] They obtained 28

percent removal of orthophosphates and 15 percent removal in phosphorus.

Jensen et.al. reported studies on pond aeration. [43] According to them, the factors such as atmospheric pressure, salinity and temperature affects the oxygen solubility in water. In summer season, most of the problems relate to oxygen depletion occur. The decreased solubility at high temperature is major reason for this. Also there is increase in respiration rate in hot climate. Also factors like sudden death of algae, turn over due to variation in density, heavy fish feeding also contribute to oxygen depletion. Portable aerators according to requirement at proper place can help to increase oxygen content of water.

Effect of Aeration on Seafood Processing Wastewater was investigated by Sunny et.al. [44] According to them most of the fish industries face problem high water consumption and high organic matter, oil and grease, ammonia, nitrogen and salt contents in the waste water. They carried out aeration with diffused fine bubble aeration apparatus. In their research, they observed that with flow rate of aeration, the percentage removal of above constituents also increased. It was also observed that salt and lipids were unaffected by the aeration. Vrecko et.al. studied various ways to control aeration in wastewater treatment plant. [45]

The use of air pressure set-point controller helped in air pressure adjustment in the common air rail according to the changes in the plant load. Oxygen concentration in aerobic reactors can be controlled by the airflow controllers. They were able to achieve 10 percent reduction in electricity consumption by using controls. Deswal et.al. carried out parameter modeling for Multiple plunging jet aeration system. [46]

They used neural network and support vector machines in their work. According to them a plunging jet aeration system is a simple and inexpensive method of supplying oxygen for wastewater treatment. They carried out investigations with single and multiple plunging jet with vertical and inclined orientation. In their investigation.

Enwereuzoh and Onyeagoro used special attention on the elimination of inhibitory oxygen that adversely affects algae growth. [47] Their method also enabled efficient transfer of carbon dioxide required to stabilize the CO₂ of the algae growth medium in a short time. Increase in the algal growth was indicated by increases in pH and decreases in dissolved oxygen concentration. However, algae grown in ammonia medium showed 17% higher growth.

CONCLUSION

Aeration is one of the important aspect of biological treatment methods. Modification of basic method includes tapered aeration, diffused aeration, deep shaft aeration etc. Various investigators have studied aeration and its advantages. Also applications of aeration in some specific applications like oil aeration, aeration of boiled sweets, aerated lightweight concrete also are investigated by various researchers.

Current review summarizes research and studies on aeration. Uniform and adequate mixing and supply of air can increase the effectiveness of aeration. Proper distribution according to requirement can save power and hence operating cost.

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