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A Study on Effect of Aeration on Domestic Wastewater

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Abstract: ***s*****Water is vital for sustaining all forms of life on earth. Treatment of domestic wastewater before its disposal into the environment was not given much importance until the recent past. This was due to increased contamination rates of surface and ground water sources. Domestic wastewater treatment is becoming even more critical due to diminishing water resources and resulting water scarcity especially during summer in many parts of the country. Aeration is one of the methods which help in the removal of various contaminants present in domestic wastewater. This paper focuses on how the various constituents of waste water vary with aeration. Diffused fine bubble aeration was done in a circular tank at various flow rates (1.5 L/minute, 3 L/minute, 4 L/minute) at time periods of 24 hours, 48 hours and 72 hours using air stones and the percentage reduction in COD, BOD and Turbidity were found out. It was found that as flow rate of aeration increased the percentage removal of above constituents also increased. Optimum removal was possible at a flow rate of 4 L/min at time period of 72 hours. BOD, COD, Turbidity were found to be removed by 95.88%, 95.71%, and 37.72% respectively.**

Keywords**: Domestic Wastewater, Aeration, Fine bubble Diffusers, COD, BOD.**

I. INTRODUCTION

Wastewater is the liquid end product or by product of municipal, domestic or an industrial activity. The term “wastewater” however implies that it is a waste product to be discarded in an environmentally sound manner. The world’s available freshwater is about 3 percent of that of total water supply. Only 20 percent of this amount is available for use in drinking water supplies. The remainder of the world is salt water, which is costly to desalinate for drinking water purposes. Consequently, the water we use for drinking, washing, bathing etc. ultimately ends up back in the stream, river. A significant element in waste water disposal is the potential impact associated with it. Environmental standards are developed to ensure that the impacts of treated waste water discharged into ambient waters are acceptable. Standards play a fundamental role in the determination of the level of waste water treatment required. The ultimate goal of waste water management is the protection of the environment in manner that safeguards public health and socio economic concerns. Hence treatment of this waste water becomes necessary so that they can be used again.

Domestic wastewater contains constituents that, if present in excess will affect the quality of groundwater and other nearby water sources and also at the same affect human life too. These constituents include micro-organisms, bio-degradable organic compounds, odour, high pH levels, metals etc.

Exceeded levels of microorganisms becomes home to pathogens, worm eggs and viruses which causes a risk when bathing and eating fish. Presence of bio degradable organic compounds reduces oxygen levels in lakes and rivers which lead to fish death and bad odour. Other organic materials such as pesticides, detergents, fat, oil & grease and solvents creates toxic effects and aesthetic inconvenience and bio accumulation in the food chain. Because of the above said problems the treatment of domestic wastewater becomes necessary.

Domestic wastewater treatment is also becoming even more critical due to diminishing water resources and resulting water scarcity especially during summer. Aeration is one of the methods which help in the removal of various contaminants present in domestic wastewater. The characteristics of wastewater having pH, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Oil, phosphorus and nitrogen (about 6% of the BOD level) at a range of value which is harmful to human and environment was found to be the major polluting sources. The process of aeration was found to be an effective method in reducing these contaminants.

Aeration was done on domestic wastewater at different air flow rates to study its effects on BOD, COD, pH, oil& grease and turbidity. Time period for aeration was kept constant but the air flow rates were varied to find the optimum flow rate and time period.

II. LITERATURE REVIEW

As per the work of Ancheng Luo et al(2002),[1] aeration can be an effective method in treating domestic waste for removal of nutrients and odour problems without causing environmental problems. Laboratory tests were conducted on pig manure to study the effect of continuous intermittent aeration at an airflow rate of 11/min.

As per a study conducted by Elif Sekmin,et al (2002),[2]the effect of aeration was investigated by means of leachate quality(COD, BOD) at 4 different aeration rates of 0.1,0.3,0.6 and 1.01/min.after75 days of operation, COD reduction was greater than 80% in all of the aerobic reactors reaching more than 85% at the end of the experiment BOD removal efficiency of reactors were determined to greater than 95%.

As per the work of Budhi Primasari et al (2011),[3] for 3 different aeration rates (no aeration, 1.5 L/min and 2 L/min) the COD, BOD, Oil and Grease content as well as pH were tested. Oil and grease removal was found in the range of 12.9 to 54.8 %, and COD removal in the range of 85.1 to 97.1%.

III. AERATION

Aeration is the process by which the area of contact between water and air is increased either by natural methods or by mechanical devices. In other words it is the method of increasing the oxygen saturation of the water. Aeration is one of the most elemental techniques frequently employed in the improvement of the physical and chemical characteristics of water.

In water treatment the aeration process brings water and air into close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air and letting them rise through the water. For both procedures the processes by which the aeration accomplishes the desired results are the same:

- Scrubbing action or Sweeping caused by the turbulence of water and air mixing together.
- Oxidation of certain metals and gases.

The scrubbing action physically removes gases from solution in the water, allowing them to escape into the surrounding air. Carbon dioxide and hydrogen sulphide can be removed by scrubbing action. It will also remove taste and odours from water if the problem is caused by relatively volatile gases and organic compounds. Oxidation is the addition of oxygen which can help in the removal of certain gases and minerals like iron and manganese from water. Once oxidized these chemicals fall out of solution and become suspended material in the water. The suspended materials can then be removed by filtration.

The efficiency of the aeration process depends almost entirely on the amount of surface contact between the air and water. This contact is controlled primarily by the size of the water drop or the air bubble.

IV. TYPES OF AERATORS

The goal of an aerator is to increase the surface area of water coming in contact with air so that more air can react with the water. The two most common aeration systems used in wastewater treatment plants are subsurface (submerged diffusers) and mechanical (surface aeration). In subsurface system air is introduced by diffusers or other devices submerged in the wastewater. A mechanical system agitates the wastewater by various means (e.g. propellers, blades or brushes) to introduce air from the atmosphere. There are several criteria to consider while selecting the right aeration technology. Energy efficiency is one of the most important followed by the system’s mixing abilities with significant differences between mechanical aerators and diffused aerators. Generally surface aerated basins do not achieve the same performance level as submerged aerators. Oxygen transfer is controlled by varying the air supply rate. Diffusers are connected to a piping system which is supplied with pressurized air by a blower. Diffusers break up the air by the displacement of the air by the dispersion of bubbles throughout the aeration tank. For good performance the rate of supply of dissolved oxygen should be equal to the rate of oxygen consumption exerted by the liquid under any given set of circumstance. Commonly used diffusion devices are:

1. COURSE BUBBLE (NON POROUS) DIFFUSERS:

Coarse bubble diffusers produce 6.4 to 13 mm bubbles which rise rapidly from the floor of a wastewater treatment plant or sewage treatment plant tank. They are typically used in grit chambers, equalization basins, chlorine contact tanks, and aerobic digesters and sometimes also in aeration tanks. Coarse bubble diffusers typically provide half the mass transfer of oxygen as compared to fine bubble diffusers, given the same air volume.

The most common types of non- porous diffusers are fixed orifices (perforated piping, sprayers and slotted tubes), valve orifices and static tubes. Coarse bubble diffusers with a check valve design can be the best choice when the goal is an aeration system that is simple to design and easy to fabricate and install in a vertical format. Coarse bubble diffusers with their rubber diaphragm cap and check valve system has been used for decades in waste water treatment plants and municipal facilities. Since the diffusers are plastic with moulded EPDM rubber check valve diaphragms they are inexpensive and readily available. The simplicity of diffuser check valve design minimizes the back flow of wastewater and debris carried with it into the piping, which can cause potential long term operational problems.

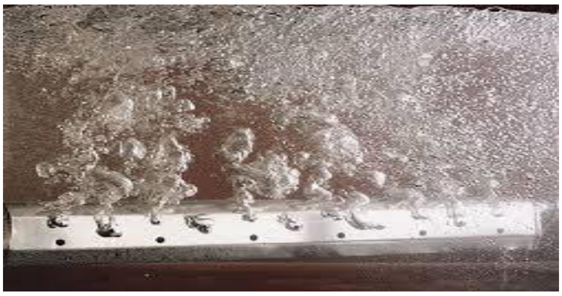

Fig 1. Coarse bubble diffuser

2. FINE BUBBLE DIFFUSERS:

Fine bubble diffusion is a subsurface form of aeration in which air is introduced in the form of very small bubbles. They exhibit high OTEs and high aeration efficiencies and can satisfy high oxygen demands. They result in lower volatile organic compound emissions than non- porous diffusers or mechanical aeration devices. But they are susceptible to chemical or biological fouling which may impair transfer efficiency and generate high head loss. As a result they require routine cleaning.

Fine bubble diffusers are mounted or screwed into the diffuser geared pipe (air manifold) that may run along the length or width of the tank or on a short manifold mounted on a movable pipe (lift pipe). Fine pore diffusers (disc, tubes, domes and plates) are usually made from ceramics, plastics or flexible perforated membranes. Although many materials can be used to make fine pore diffusers, only these few are being used due to cost considerations, specific characteristics, market size and other factors. Ceramic media diffusers have been in use for many years and have essentially became the standard for comparison since, in the past, they were the primary media in the fine pore aeration market.

Fig 2. Fine bubble diffuser

3. OTHER DIFFUSION DEVICES:

Injectors mix air and water together by providing a jet of water containing air bubbles. In turn, this jet of water creates good horizontal movement of the water. This form of aeration is often very efficient, and as such the processes can be used for injecting oxygen into the water. However, when the process is used with air, super saturation with nitrogen gas can occur. This leads to possible gas bubble trauma or sub lethal toxicological problems.

There are a wide variety of surface agitators such as paddle wheels and pumps. Each of these systems expends a great deal of kinetic energy in throwing large quantities of water into the air. This means that energy is not directly used to aerate or mix the water in the fish culture system.

There are also jet aerators which discharge a mixture of air and liquid through a nozzle near the tank bottom; aspirators mounted at the basin surface to supply a mixture of air and water and U tubes where compressed air is discharged into the down leg of a deep-vertical-shaft.

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V. METHODOLOGY

1. SAMPLE COLLECTION AND STORAGE:

Domestic wastewater samples were collected from the ladies hostel of M.A College of engineering for 7 consecutive days for different time periods. Necessary tests were conducted and it was found that the wastewater contained COD, BOD, oil and grease in higher values than permitted for surface discharge and its direct disposal leads to harmful effect on environment. The sample was collected in sterilized bottles. Sufficient care was taken to obtain a sample that is a true representative of existing condition and to handle it in such a way that it does not deteriorate or become contaminated before it reached the laboratory. The samples were preserved in the refrigerator during storage.

2. ANALYSIS:

Analysis was done on samples before and after aeration. The different laboratory tests conducted were

- Chemical Oxygen Demand(COD)
- Biochemical Oxygen Demand(BOD)
- pH
- Turbidity
- Oil and grease

3. FINE BUBBLE DIFFUSERS:

Fine bubble diffusers have more oxygen transfer efficiency than coarse bubble diffusers. Coarse bubble diffusers are more economical and require less maintenance, but have lower oxygen transfer efficiency. Air stones were used as diffusers.

They were preferred because,
Dust and dirt particles up to 30micron can pass through it
No air filters are needed.
Produce uniform fine bubble.

4. AERATION TANK:

Circular tank was used for aeration. It was found that the circular tanks are the most energy efficient. As per Achanta Ramakrishna Rao et al circular tanks produce maximum energy efficiency for a given input energy, followed by square tanks, rectangular tanks of L/W equal to 1.5 and rectangular tank of L/W equal to 2. This suggests that the circular tanks perform the better as far as power requirements are concerned and hence provide better economy. Although the square tanks were the best for quick aeration, they consumed more energy than the circular tank. For circular aeration tanks, 0.287m to 0.430m diameter and 0.186m to 0.279m depth is required. So the height (H) to diameter (D) ratio required is 1.5, i.e./D = 1.5.Since a small replica of actual aeration tank is needed to find the effect of aeration, an effluent discharge of 4000cm^3/day is considered.

$$H \times \left(\left(\frac{\pi}{4}\right) \times (1.5H)^2\right) = 4000.$$

So, height was selected as 30 cm and corresponding diameter as 20 cm. Also, a freeboard of 5cm was provided.

Fig 3: Aeration tank and airflow controlling devices

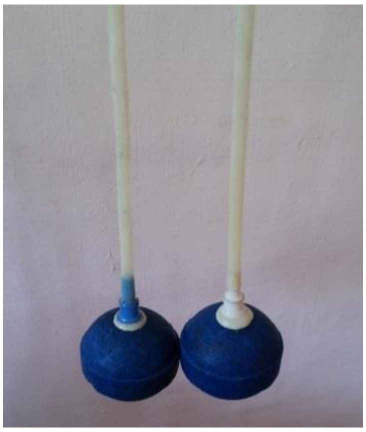

Fig 4: Airstones

VI. RESULTS AND DISCUSSION

From the initial analysis of sample it was found that BOD, COD, pH, Turbidity and oil and grease were exceeding their permissible limits. The characteristic of wastewater before treatment is shown in Table 1:

TABLE 1: Characteristics of wastewater

PARAMETERS	INITIAL VALUE (mg/L)
COD	3705.88
BOD	1985.52
pH	6
TURBIDITY	289
OIL AND GREASE	2.17

After treatment was started, initially wastewater was analyzed for a flow rate of 1.5L/min and an aeration period of 24hrs.The results obtained are given in Table 2.

TABLE 2: Characteristics of wastewater after providing aeration at a flow rate of 1.5 l/min for aeration period of 24 hours

PARAMETERS	OBTAINED VALUE AFTER AERATION (24 HOURS) (mg/L)	%REMOVAL
COD	1693.96	43
BOD	761.85	61.62
pH	6	--
TURBIDITY	230	20.42
OIL AND GREASE	2.17	--

Next wastewater was analyzed for a flow rate of 3L/min and an aeration period of 24, 48 & 72hrs.The results obtained are given in Table 3.

Table 3: Characteristics of wastewater after providing aeration at a flow rate of 3 l/min for aeration period of 24, 48 and 72 hours

PARAMETER	OBTAINED VALUE AFTER AERATION (24 HOURS) (mg/L)	% REMOVAL	OBTAINED VALUE AFTER AERATION(48 HOURS) (mg/L)	% REMOVAL	OBTAINED VALUE AFTER AERATION (72 HOURS) (mg/L)	% REMOVAL
COD	533.6	85.6	657.85	82.24	220.19	94.05
BOD	220.16	88.91	398.22	79.95	129.34	94.17
pH	6	--	6	--	6	--
TURBIDITY	192	33.57	192	33.57	192	33.57
OIL & GREASE	2.17	--	2.17	--	2.17	--

As the next step wastewater was analyzed for a flow rate of 4L/min and an aeration period of 24 ,48 & 72 hrs. The results obtained are given in Table 4.

Table 4: Characteristics of wastewater after providing aeration at a flow rate of 4 L/min for aeration period of 24, 48 and 72

PARAMETER	OBTAINED VALUE AFTER AERATION (24 HOURS) (mg/L)	% REMOVAL	OBTAINED VALUE AFTER AERATION(48 HOURS) (mg/L)	% REMOVAL	OBTAINED VALUE AFTER AERATION (72 HOURS) (mg/L)	% REMOVAL
COD	252.616	93.18	182.84	95.06	158.78	95.71
BOD	150.56	92.41	109.7	94.45	91.35	95.88
pH	7	--	7	--	7	--
TURBIDITY	180	37.72	180	37.72	180	37.72
OIL & GREASE	2.17	--	2.17	--	2.17	--

Hence optimum air flow rate was obtained as 4 L/min and optimum time period was found to be 72 hour.

After optimum flow rate and aeration period was found comparison of these effluent parameters with WHO Water Quality Standards were done whose result is shown in Table 5

Table 5: Final Values (at optimum flow rate and aeration period) and WHO Water Quality Standards

PARAMETERS	**FINAL VALUES**(mg/L)	**WHO WATER QUALITY STANDARDS**(mg/l)
BOD	91.35	30
COD	158.78	250
pH	7	6.5-7.5
TURBIDITY	180	5-10
OIL AND GREASE	2.17	10

VII. CONCLUSION

Aeration was done on sample wastewater at different flow rates of 1.5L/min, 3L/min, and 4L/min. It was found that as flow rates increased the percentage removal of above constituents also increased. Time period of aeration can also be varied in addition to air flow rate. Different time period of aeration such as 24 hrs. 48 hrs. 72 hrs. were adopted. Percentage removal of different parameters also varied with the change in time period. It was found that as time period of aeration increases, there was more reduction in the parameters. Optimum removal was possible at flow rate of 4L/min for a detention period of 72 hours. BOD, COD, Turbidity were found to be removed by 95.88%, 95.71%, and 37.72% respectively.

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