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A Review Of Management Of Wastes From Bakery Industries In India

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Abstract –
India is the world's second-largest producer of biscuits after the USA. In the food processing sector in India, the bakery sector comprises the largest segment and offers huge potential for growth. In India, there are more than 2,000 organized or semi-organized bakeries producing around 1.3 million tonnes and 1,000,000 unorganized small-scale bakeries producing 1.7 million tones of the bakery products. In bakery industries, waste management system should be such that there is no risk of contaminating food or potable water supply. There should be proper facilities for storage of biodegradable & non-biodegradable wastes separately. Wastewater is normally treated by physical, chemical and biological processes. Disposal of sewage & effluents shall be done in conformity with specified requirements of factory act/ state pollution control board.

Keywords - *Bakery waste, Biodegradable, Non-biodegradable wastes, Wastewater, Waste disposal*

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1. INTRODUCTION

Bakery products are gaining popularity day by day among the people of all age group, due to their high nutritive value and low price [1]. The bakery industry is one of the world's major food industries and varies widely in terms of production scale and process [2]. India holds the second position in the world after USA in the production of biscuits. In the food processing sector in India, the bakery sector comprises the largest segment and offers huge potential for growth [1].
Industrial pollution is still a major concern for sewage treatment and waste management system should be strong so that there is no risk of contaminating food or potable water supply. Improper waste management can cause environment pollution, climate change, deteriorate public health, accelerate degradation of natural resources and ultimately affect adversely the quality of life of citizens [3]. Bakery wastewater is mainly produced from cleaning of equipments and washing of floor. Bakery industry waste is generally nontoxic. In the liquid waste, there are high contents of organic pollutants including chemical oxygen demand, BOD_5, as well as fats, oils and greases and suspended solids. The properties of the industrial wastewater are highly variable and specific for each industrial activity. It is possible to treat bakery wastewater to achieve the desired Carbon: Nitrogen: Phosphorous ratio by effective de-nitrification and biological phosphorus removal [4], [5].

2. PROPERTIES OF WASTE FROM BAKERY INDUSTRIES

The bakery industry is one of the largest water users and more than half of the water is discharged as wastewater [2], [4]. Bakery wastewater is mainly produced from cleaning of equipments and washing of floor. It contains large amounts of flour, sugar, oil, grease, and yeast [2]. Generally, bakery industry waste is nontoxic. The bakery wastewater is biodegradable; hence, the biological treatment can be effective in reducing biological oxygen demand. Bakery wastewater is acidic, high in BOD_5, suspended solids and grease and oil. The bakery effluent particularly from bread industry contains yeast that is the major source of pollution. This effluent has a high biological oxygen demand (BOD), high chemical oxygen demand (COD), total nitrogen. It is dark in color, and contains non-biodegradable organic pollutants [4]. The characteristics of waste water from bakery industries are shown in table 1.

TABLE 1: CHARACTERISTICS OF WASTE WATER FROM BAKERY INDUSTRIES

Characteristics	Parameters for plants of		
	Bread	Cake	Other Varieties
pH	6.9-7.8	4.7-8.4	5.6
BOD_5 (mg/L)	155-620	2240-8500	1600
SS (mg/L)	130-150	963-5700	1700
TS (mg/L)	708	4238-5700	-
Grease (mg/L)	60-68	400-1200	630

Source: Ref. [2]

Solid wastes generated from bakery industries are principally waste dough and rejected products and package waste. This waste may be recovered by cooking waste dough to produce bread crumbs and using cooked products as feed and fodder [2], [3].
The standards for emission or discharge of environmental pollutants from bakery industries in India as per the Environment (Protection) Act, 1986 are shown in table 2.

TABLE 2: INDIAN STANDARDS FOR DISCHARGE FORM BAKERY INDUSTRIES

Category	Parameters	Standards	Quantum
A. Bread & Biscuits			
1. More than 20T/Day	pH	6.5-6.8	
	BOD(3 days at 27°C)	200 mg/L	25gm/MT of Product
2. Less than 20T/Day		Disposal via septic tank	
B. Biscuit Production			
1. 10T/Day and above	pH	6.5-6.8	
	BOD(3 days at 27°C)	300 mg/L	35gm/MT of Product
2. Below 10T/Day		Disposal via septic tank	

Source: Ref. [6]

3. TREATMENT OF BAKERY WASTE

Bakery waste can be divided into liquid waste, solid waste, and gaseous waste. Liquid waste in Indian bakery contains high amount of organic pollutants including chemical oxygen demand (COD), biological oxygen demand (BOD_5), as well as fats, oils, and greases (FOG), and suspended solids (SS). Wastewater is normally treated by physical and chemical, biological processes [4].

Large commercial bakeries generate wastewater with high loads of contaminants which cannot be discharged to a municipal sewerage system without pretreatment.

3.1. Pretreatment

Pre or primary treatments are the combination of various physical and chemical operations that helps in the collection of raw and unstable sludge, which must be properly disposed of before it creates a nuisance. Pretreatments generally involve screening, flow equalization and neutralization, FOG separation, coagulation–sedimentation, and dissolved air flotation [4].

Screening is used to remove larger objects in the influent that might plug the pipes. Generally the screens of stainless material are used. These screens may be static, moving, centrifugal or tangential. The capacity of these screens can be as high as 0.13 m^3/sec and the head loss ranges from 0.8–1.4 m. Depending on the design and operation, BOD_5 and SS removal efficiencies are 5–50% and 5–45%, respectively [7], [8].

In bakery plants, the flow rate of wastewater and the loading vary with the time. To meet the peak discharge demand, the use of flow equalization tank is usually economical. However, too long retention time may result in decrease in pH and bad odors due to anaerobic environment [2].

In the bakery industry, the waste contains high SS and floatable FOG therefore pretreatment is always required. Pretreatment using a DAF in commercial bakeries allows for a reduction of FOG (fats, oil and grease) by 99% and Total Suspended Solids (TSS) by 97% [4].

Sedimentation or clarification is used to remove readily settleable solids on the basis of density difference and allows SS with larger particle sizes to settle down easily. Rectangular tanks, circular tanks, combination flocculation–clarifiers, and stacked multilevel clarifiers are generally used. Collected sludge contains about 2-6% solids and should be concentrated before final disposal [8], [9].

In dissolved air flotation (DAF), the compressed air bubbles are implemented by pump to remove fine SS and FOG in the bakery wastewater. The air bubbles are formed due to the sudden reduction in the pressure. These fine air bubbles attach themselves to the SS and FOG and rise to the surface. The dosages of coagulant and control of pH are the important factors in the removal of SS, BOD, COD, and FOG. Other influential factors include the solids content and air/solids ratio [9]. Liu and Lien [10] found that bakery wastewater preconditioned by alum and ferric chloride and treated with DAF, 48.6% of COD and 69.8% of SS were removed in 10 minutes at pressure of 4 kg/cm^2, at pH 6.0.

Coagulation and flocculation processes are used to separate the suspended solids portion from the water. Chemical coagulants commonly used in treatment of wastewater include alum, ferric chloride, ferric sulphate, ferrous sulphate, lime, etc. The colloidal particles are gathered to form settleable solids by the process of flocculation [11]. Coagulation is used for destabilization of the stable colloid suspension, while flocculation is used to enhance the coagulation and inter-particle contact. The suspended solids become heavier and larger enough and settle down [12]. The Coagulation–flocculation process can be used to remove fine SS from bakery wastewater [10]. Yim et al. [8] used coagulation–flocculation to treat a higher organic content, SS, and FOG. They suggested that coagulation & flocculation treatment can also be used for high-strength bakery waste. Liu and Lien [10] used alum and ferric chloride to treat wastewater from a bakery and found that the values of 55% and 95–100% for removal of COD and SS, respectively, were achieved. It was also found that ferric chloride was relatively more effective than alum.

3.2. Biological Treatment

The objective of biological treatment is to remove the suspended, dissolved and particulate biodegradable components in the wastewater by converting them to settle-able by bio-flocculation or biomass formation. In this treatment, microorganisms are used to decompose the organic wastes [7], [13], [14].

Biological treatment can be classified as per oxygen utilization: aerobic, anaerobic, and facultative. In the aerobic system, the organic matter is decomposed to CO_2, water, ammonia and a series of simple compounds. In the anaerobic system, the final products are CO_2, water and methane. The aerobic treatment has better quality effluent, easier operation, less solid retention time, but higher cost for aeration and excess sludge, as compared to anaerobic treatment [2], [14].

Suspended growth systems and attached growth systems are two of the main biological wastewater treatment processes. The activated sludge process is the suspended growth system most commonly used in treatment of bakery wastewater. The trickling filter is the commonly used attached growth systems in bakery. It is easy to control, and has less excess sludge. Its energy cost is low and has high resistance loading. However, high operational cost is its major disadvantage. In addition, it is more sensitive to temperature and has odor problems [2].

3.2.1. Activated Sludge Process

In the activated sludge process, the suspended growth microorganisms are employed. Activated sludge process consists of a pretreatment process, aeration tank, final sedimentation, and excess sludge treatment. Pretreatment processes include mainly screening and clarification, while excess sludge treatments include anaerobic treatment and dewatering process. The microorganisms are separated from water by final sedimentation. In order to enhance the performance result, most of the sludge from the sedimentation is recycled back to the aeration tank, while the remaining is sent for anaerobic sludge treatment [14].

According the case study of Givens and Cable [15], due to the high organic load, bakery wastewater is not recommended to be treated directly by aerobic treatment processes. The treatment of bakery wastewater may be more cost-effective, if the waste is first treated by anaerobic treatment and then by aerobic treatment.

3.2.2. Trickling Filter

Aerobic attached-growth processes include tricking filters and rotating biological contactors (RBC). In these processes, microorganisms are attached onto solid media and form a layer of bio-film. The organic pollutants are first adsorbed to the bio-film surface, oxidation reactions then occur, which break the complex organics into a group of simple compounds, such as water, carbon dioxide, and nitrate. The energy that is released from the oxidation reactions is utilized for the maintenance as well as synthesis of microorganisms [14].

Keenan and Sabelnikov [16] reported that the biological system that was containing mixing aeration tank and trickling filter, was efficient in eliminating grease and oil (FOG) from bakery waste. The reduction of FOG content from 1500 mg/L to less than 30 mg/L was achieved. That system was fairly stable during continuous operation of 20 months.

3.3. Advanced Wastewater Treatment

Advanced wastewater treatment processes are gaining importance as means of improving the quality of waste treatment effluent. These systems include microstrainers, multi-grade filters, activated carbon filters, various membrane filters, coagulation & floculation and Dissolved Air Floatation (DAF) [17]. These treatments are also called Tertiary waste treatment and applied to food processing wastewaters to remove pollutants unusual to food processing such as colour, odour, salt and flavour compounds. These treatments are generally used, when recycling of water is required [18].

Microstrainers are used to remove fine particles that are carry forwarded from secondary wastewaters. These systems are fast, low cost and require low operator attendance. Microstrainer consists of a rotating drum that is supported by very fine stainless steel or nylon screen. This drum is mounted in an open tank in a horizontal position. This is a self cleaning system. The solids that are retained on the screen are flushed by a pressurized backwash system [19].

Multi-grade filters are designed to increase the working efficiency of the filter media by prolonging the filtration time before the requirement of backwashing. It works on the hypothesis that if coarse media is arranged at the top and the fine media at the bottom, the filtration efficiency increases [20]. The filtering media generally used are : anthracite (coal) of size 1.2 – 1.4 mm and specific gravity 1.6; sand of size 0.6mm and specific gravity 2.6; garnet of size 0.3mm and specific gravity 4.2; ilmenite of size 0.3 mm and specific gravity 4.5 [21]. On backwashing, these different media remain in their place due to differences in specific gravity. The latest advancements in these filters are up-flow, bi-flow or moving bed filters. The advantage of Moving bed filters are continual operation and large concentrations of waste solids can be filtered without blinding [20].

Activated carbon adsorption is the system in which soluble substances are collected within a solution on a solid interface. By this method, very fine discharge matter present in the water may also be removed [22]. Activated carbon is prepared by heating of charcoal to a high temperature and then it is activated by the exposure to an oxidizing gas. The porous structure of activated carbon creates a large internal surface area. The common types of activated carbon used are granular activated carbon (GAC) having size greater than 0.1 mm and powdered activated carbon (PAC) having size of less than 200 mesh [23].

Several membrane separation techniques are being used for treatment of secondary wastewater. These techniques are reverse osmosis, ultra filtration, ion exchange, nano-filtration, electro-dialysis [24]. RO membranes are generally made-up of cellulose acetate and polyamides [25]. UF membranes are generally made-up of cellulose acetate, polypropylene, polysulfone, polyacrylonitrate, polyvinylchloride etc. [26]. The ion exchange resins usually consists of cross- linked polymers that contain reactive functional groups such as carboxylic or sulfonic [27]. In nanofiltration, m-phenylene isophthalamide) / graphene oxide (PMIA/GO) composite membranes are used for treatment of water [28], [29]. Ion selective membranes are used in case of electro-dialysis of secondary wastewater [30].

Dissolved Air Floatation (DAF) technique is also used for advanced wastewater treatment and normally involves air forced under pressure into a portion of the wastewater. Air bubbles can be created by rotating impellers or air diffusers, by saturation of the liquid medium with air using vacuum, or by saturation of air with liquid under high pressure with subsequent release of pressure [31]. Chitosan is commonly used as flocculating agent in DAF treatment [32].

4. SOLID WASTE MANAGEMENT

Food waste, by products that are not edible and other refuse shall not be allowed to accumulate in food production, handling or storage areas. It shall be removed periodically with a minimum daily removal so as to avoid accumulation and overflow in food handling, food storage, other working areas and adjoining environment. Removal and destruction should be carried out by approved disposal contractors [1]. Bakery solid waste includes stale bakery items, spilled materials and packages. The common and simplest way to discard this waste is to transport directly to landfill or incineration. Landfill can cause the waste to decompose, which eventually leads to production of methane and groundwater pollution (heavy metals). Incineration of bakery waste can also release nitrogen oxide gases [33]. Anaerobic digestion may be a better option for production of biogas for which wastes from animal rearing could serve as co-substrates [34].

Reclamation of the bakery waste may play an important role in its management. The waste consists primarily of stale bread and cookies can be fed directly to animals as it is a good source of energy. This waste may also be used for production of valuable products like lactic acid. Oda et al. [35] used bakery waste to produce lactic acid with a good conversion efficiency of 47.2%.

Disposal of sewage & effluents shall be done in conformity with specified requirements of factory act/ state pollution control board. Waste stores and bins must be kept appropriately clean, free of pests and in closed conditions and shall be disposed as per local rules and regulations.

5. CONCLUSION

Industrial pollution is a major threat to environment protection in India and there is a dire need of systematic pollution control efforts. As the waste generated from bakery industry is biodegradable in nature, it can be easily treated with physical and biological treatments. The treated wastewater may be discharged into the stream of municipal sewage or if contains enough nutrients concentrations, N, P, K could serve as liquid fertilizer and does not cause operational problems. Solid wastes generated from bakery industries may be used as animal feed after processing. Disposal of sewage & effluents shall be done as per the requirements specified in The Environment (Protection) Act, 1986.

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