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Sustainable Solutions: Managing Effluent from Abattoirs

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Abstract

Effluent generated from slaughterhouses and meat processing facilities poses significant environmental and health risks due to its complex composition, including dissolved and suspended matter. The meat industry's extensive water usage results in the production of wastewater from various stages of operations, such as lairage, slaughtering, and cleaning processes. The disposal of this effluent without proper treatment can lead to severe pollution of water sources and surrounding environments. Effluent treatment is essential to mitigate these risks, with primary, secondary, and tertiary treatment stages aimed at removing contaminants and reducing the biological oxygen demand (BOD). Effluent characteristics, including biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride content, suspended solids, and pH, highlight the diverse pollutants present in slaughterhouse effluent. Efficient treatment methods are crucial for meeting recommended discharge limits and minimizing environmental impacts. Combining anaerobic and aerobic methods proves effective in treating slaughterhouse effluent, achieving high removal rates of BOD, suspended solids, and grease. Final treatment ensures the safe dispersal of treated effluent back into the environment. Overall, proper effluent treatment is essential for preventing environmental pollution, maintaining water quality, and ensuring the sustainability of slaughterhouse operations. Various treatment methods, including screening, sedimentation, coagulation, flocculation, and activated sludge processes, play crucial roles in addressing the challenges posed by slaughterhouse wastewater.

Key words: Slaughterhouse wastewater, Effluent treatment, Environmental pollution, Water quality, Sustainable meat processing

Introduction

The waste-water effluent, as per FAO (1991), refers to the used water from a community or industry, containing dissolved and suspended matter. Approximately 99% of this effluent is liquid, with the remaining 1% being solid waste. Industrial wastewater, characterized by diverse chemical properties

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and constituents, originates from various sources, as highlighted by Bielefeldt (2009). In the meat processing industry, the major sources of waste include the lairage area, slaughtering, hide or hair removal, eviscerating, carcass washing, trimming, and clean-up operation (USEPA, 2004). Effluent treatment within meat processing facilities aims to mitigate the environmental impact of wastewater discharge, ensuring compliance with recommended discharge limits. Key considerations in treatment processes include the separation and treatment of by-products such as blood, fat, and manure, which significantly contribute to the biochemical oxygen demand (BOD) of effluent streams. Additionally, slaughterhouse activities exert direct and indirect impacts on nearby environments and residents, with inadequate effluent disposal exacerbating issues such as air and water quality degradation, noise, and odor pollution.

Effluent characterization plays a pivotal role in designing appropriate treatment methodologies, with parameters such as BOD, chemical oxygen demand (COD), chloride content, and suspended solids informing treatment strategies. Treatment methods encompass a range of primary, secondary, and tertiary processes, each tailored to remove specific contaminants and achieve desired effluent quality. Notably, the combination of anaerobic and aerobic treatment methods has demonstrated efficacy in addressing the complex composition of slaughterhouse effluent, yielding significant reductions in BOD, suspended solids, and grease content.

This article comprehensively examines the sources, characteristics, and treatment of slaughterhouse effluent, emphasizing the importance of implementing robust effluent treatment systems to mitigate environmental pollution and safeguard water quality. By exploring various treatment methodologies and their efficacy in addressing the challenges posed by slaughterhouse wastewater, this study contributes to the ongoing discourse on sustainable wastewater management practices in the meat processing industry.

Sources of Effluent in Slaughterhouses

The meat industry uses large quantities of water especially for cleaning and processing

Table 1: Sources of waste generated in abattoir

Process	Generated waste
Lairage (Stockyard)	Dead animals, straw and fodder
Slaughtering (exsanguination)	Blood
Removal skin (skinning)	Blood. hair
Meat inspection	Rejected meat
Channel management	Cutting waste, pieces of meat, fat
Management of viscera	Stomach or intestinal contents
General Cleaning	Pieces of flesh. blood clots
Tanning	Wastewater with high salt content

purpose industry effluents mainly produced from lairage, slaughter and bleeding, dressing area, gut handling area, rendering unit and processing and cleaning section (Table 1).

Importance of Effluent Treatment

The importance of efficient effluent disposal from meat plants and processing facilities arises due to potential environmental and water source pollution. Slaughterhouse effluent discharge has been linked to river deoxygenation (Quinn and Farlane, 1989) and groundwater contamination (Sangodoyin and Agbawhe, 1992). Consequently, the presence of an effluent treatment plant (ETP) is deemed essential in all modern abattoirs and meat plants. The meat industry, a significant consumer of water, incurs substantial processing costs. Treatment within the plant and subsequent disposal to sewers add to overheads, necessitating careful water use. Ideally, the eventual waste load should not exceed 7.5 kg per 500 kg live weight slaughtered, wastewater usage should stay below 5000 litres per 500 kg live weight slaughtered, and BOD should be around 1500 mg/later.

Various systems are available for treating meat plant effluents, with onsite treatment being a prerequisite, eliminating the need for final treatment in a local authority sewage plant. The processing of carcasses and resulting by-products yields substantial amounts of highly polluting wastewater, semi-solids, and solids. These must be separated and treated before discharge into the environment. The ultimate goal of effluent treatment is to produce a product that can be safely released into a waterway or sewer, complying with recommended discharge limits.

Factors determines the nature or quality of slaughterhouse effluent.

The most crucial measure for reducing BOD, is the degree of separation of by-products like blood, fat, manure, and undigested stomach contents from the effluent stream, with special attention to blood retention during animal bleeding (Hansen, 1992).

Environmental Impacts of Slaughterhouse effluent

Slaughterhouse activities exert both direct and indirect impacts on the built environment and the health of nearby residents, particularly in areas close to slaughterhouses. The absence of a specialized or effective effluent disposal system, as noted by Bandaw, and Herago (2017), intensifies the negative impact on air and water quality for residents within the slaughterhouse vicinity. Key environmental concerns related to slaughterhouse operations include substantial water and energy consumption, the production of high-strength effluent streams and by-products, and potential issues such as noise and odour for specific locations.

Characteristics of Slaughterhouse effluent

Effluent characterization involves assessing its physical, chemical, and biological composition. This process is crucial for designing and selecting appropriate treatment methods, determining the required extent of treatment, evaluating the beneficial uses of wastes, and utilizing the purification capacity of natural bodies of water in a planned and controlled manner. It's important to note that many physicochemical and biological characteristics are interconnected. For instance, temperature, a physical property, influences both the levels of gases dissolved in the effluent and the biological activity within the effluent (Metcalf, 2003).

Pollution Parameter of Abattoir Effluent

1. ***Biochemical oxygen demand (BOD):*** It's a measure of the readily biodegradable material in an effluent. It is obtained by measuring the oxygen consumed by aerobic organisms, when a known volume of the effluent is added to a known volume of oxygen-saturated water and incubated at 20°C for 5 days. It is generally used to determine the concentration of pollutant remaining after treatment and prior to Discharge (Law Yong, et al., 2018) (Table 2).

Table 2: Biological oxygen demand (BOD) of different food animal slaughterhouse

Sources	BOD mg/Litre
Poultry slaughterhouse	1000-1200
Pig slaughterhouse	1500-2000
Cattle/ sheep/ Goat slaughterhouse	1400-3200
Fish processing	1000-3000

2. ***Chemical oxygen demand (COD):*** It's a measure of the oxygen required for the oxidation of all Organic matter in a known volume of effluent, using a standard technique. The COD is often used as a Cheaper and more accurate means of determining the oxygen requirements of an effluent before treatment. Tritt and Schuchardt (1992) reported a COD level as high as 2,785,000 mg/L For raw bovine blood.
3. ***Chloride (Cl):*** It's a measure of salinity. Effluent especially coming from rendering unit and tannery Contain high amount of chloride content which may contaminate soil and drinking ground water.
4. ***Dry matter (DM) or total solids (TS)***: These are the final weight of a known amount of effluent that has Been dried to a constant weight at 105 °C over 24 h. It is measured in g/litre or mg/litre. According to Mittal (2004), abattoirs effluents contain the TS

concentrations between 2,333 – 8,620 mg/L.

5. ***Grease, fat and oil (FOG):*** These are a group of substances having common properties of immiscibility with water and a lower specific gravity, which cause them to float. Concentrations are measured by the Amount of solvent required for the effluent to become soluble. Some water authorities in the United Kingdom will accept a level of 100 mg/litre. The substances tend to coat treatment systems, clogging Pipes, pumping systems and screens. They reduce oxygen transfer and can seriously reduce the efficiency Of aerobic treatment systems.
6. ***pH:*** It's a measure of the acidity or alkalinity of an aqueous solution. Pure water has a pH value of 7.0.
7. ***Nitrogen (N):*** Nitrogen occurs in three forms in effluents: organic nitrogen, ammonium salts and dissolved Ammonia gas, and as nitrates which are found in aerobically treated effluents. Ammonia in solution is Toxic to aquatic life; the maximum discharge to sewers is 40 mg / litre. High nitrate concentrations in Natural waters encourage algae and other plant growth, thus blocking watercourses. The maximum level In potable water is 0.5 mg / litre., From Abattoirs effluent, average levels of nitrogen and phosphorus Were evaluated at 6 and 2.3 mgL-1 (Mittal, 2004)
8. ***Pathogenic bacteria***: Potable water should not contain any Coliform organisms.
9. ***Suspended solids (SS):*** It refers to matter, which is insoluble and is suspended in the water. It consists of both organic and inorganic components. The organic material will eventually be degraded and add to the BOD.
10. ***Temperature:*** The effluent produced from slaughterhouse usually have high temperature which disturb the natural ecosystem of the river and water body.
11. ***Turbidity and colour:*** Effluent from slaughterhouse is highly coloured. If the red color observed Originates from blood (Gnokam-Zumgang et al., 2010), the green colour is certainly due to the Chlorophyll in plant species that slaughtered animals naturally consume (Folly and Engel,1999).

Basic Principles of Effluent Treatment

Designed for the safe return of both water and contaminants to the environment, effluent treatment systems aim to remove contaminants from wastewater.

Effluent treatment includes:

1. ***Preliminary/ Primary treatment***: Includes physical removal of large objects, rags, and grit.
2. ***Secondary treatment***: Biological and chemical processes are used in

secondary treatment to remove most of the organic matter and in certain instances, nitrogen and phosphorus.

3. ***Tertiary treatments:*** Includes removal of finer particles and other constituents such as pathogen that cannot be removed by conventional secondary treatment and disinfection.

General effluent treatment methods

Primary/preliminary treatment

In primary treatment, three methods are employed: screens, air floatation, and physico-chemical treatment. Floating particles are skimmed from the surface, while heavy particles undergo removal through quiescent settling or sedimentation. Advanced primary treatment may involve the addition of chemicals to improve sedimentation, particularly for the removal of lighter suspended solids and, to a lesser extent, dissolved solids.

Secondary treatment/ Biological treatment

The selection of the most suitable secondary system is dependent on factors such as costs, required BOD level, available land area, odour level, and more (Metcalf, 2003). Biological treatment systems are employed for secondary treatment, wherein a mixed culture of microorganisms is maintained under controlled conditions. These microorganisms utilize the continuous supply of organic matter in the effluent to synthesize new cells. Anaerobic processes, involving bacteria performing BOD reduction in the absence of oxygen, may also be employed. It has been observed in pond treatment technology in which ponds loaded to 7.5 BOD per 5000 litres pond volume, with a depth of 4.5 m, can achieve a BOD reduction of 60-80 %, especially at temperatures of 32.5ºC (Shilton, 2006).

Anaerobic treatment

To prevent the entry of air, this process is conducted in totally enclosed systems, resulting in a rapid reduction of organic material and the production of biogas (Figure 1). It becomes advantageous when dealing with a BOD higher than 2000 mg/litre. The system operates as a two-stage fermentation process, where both stages occur simultaneously within the digester. In the first stage, bacteria break down complex organic substances into simpler compounds, with volatile fatty acids (VFA) being the most crucial. During the second stage, methanogenic organisms utilize the VFA to produce methane and carbon dioxide or biogas.

Aerobic treatment

Bacteria utilize organic matter for their cell synthesis in the presence of air. Organic carbon is converted into CO_2, nitrogen, or nitrate ions (Figure 1). Before discharging anaerobically treated wastewater into waterways, it undergoes aerobic treatment to eliminate most residual BOD and suspended solids. This process also oxidizes NH^3 and H_2S into less harmful nitrate and sulfate.

the anaerobic-aerobic lagoon system for slaughterhouse wastes achieved an overall BOD removal of 99%, suspended solids removal of 98%, and grease removal of 98%.

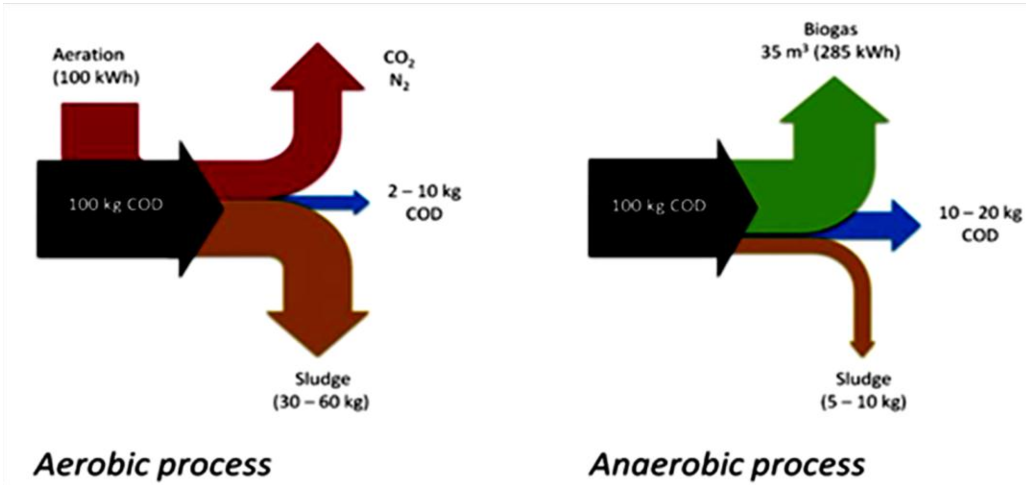

Figure 1: Principal components generated from anaerobic and aerobic treatment

Anaerobic treatment offers several advantages over aerobic treatment:

- ✓ It produces useful end products, including methane and digested sludge.
- ✓ There is a low nutrient requirement when treating nutritionally unbalanced wastes.
- ✓ Aeration does not demand energy.
- ✓ It enables the rapid dewatering of sludge, making subsequent handling easier.
- ✓ High loading rates can be achieved compared to aerobic treatment.

Combination of anaerobic-aerobic method

The most suitable effluent treatment for meat industries is a combination of anaerobic-aerobic methods. According to Loehr (1974),

Another effective approach involves a combined system of anaerobic lagoons followed by trickling filters for meat packing wastes, resulting in the removal of 74% BOD, 73% COD, and 69% grease, respectively.

Final treatment

After secondary treatment, both sludge and treated water are obtained. Final treatment involves the ultimate removal of contaminants, facilitating the dispersal of effluent back into the environment. Various options are available for distributing effluent in soil.

Conclusion

In conclusion, the management of slaughterhouse wastewater presents multifaceted challenges necessitating comprehensive and sustainable solutions.

Throughout this study, we have delved into the sources, characteristics, and treatment methodologies of slaughterhouse effluent, highlighting the critical importance of effluent treatment in mitigating environmental pollution and preserving water quality. From the diverse sources of waste within meat processing facilities to the intricate parameters involved in effluent characterization, it is evident that addressing the complexities of slaughterhouse wastewater requires a holistic approach. Effluent treatment systems, encompassing primary, secondary, and tertiary processes, play a crucial role in removing contaminants and ensuring compliance with discharge regulations.

Moreover, the environmental impacts of untreated slaughterhouse effluent underscore the urgency of implementing robust treatment measures. From the depletion of oxygen levels in water bodies to the contamination of groundwater sources, the repercussions of inadequate effluent disposal extend far beyond the confines of slaughterhouse premises. Moving forward, it is imperative for stakeholders in the meat processing industry to prioritize the adoption of sustainable wastewater management practices. By investing in efficient treatment technologies and adhering to stringent regulatory standards, we can minimize the environmental footprint of slaughterhouse operations while safeguarding public health and ecosystems. In essence, this study underscores the pivotal role of effluent treatment in fostering environmental sustainability within the meat processing industry. By addressing the challenges posed by slaughterhouse wastewater head-on, we can pave the way towards a future where responsible resource management and environmental stewardship go hand in hand.

References

1. Bandaw, T., & Herago, T. (2017). Review on abattoir waste management. Global Veterinaria, 19(2), 517-524.
2. Bielefeldt, A.R. (2009). Encyclopaedia of Microbiology, Water Treatment, Industrial, 569–586.
3. FAO, 1991. Available at https://www.fao.org/3/t0551e/t0551e05.htm, Accessed on 17/02/2024.
4. Folly, P., & Engel, N. (1999). Chlorophyll b to chlorophyll a conversion precedes chlorophyll degradation in Hordeum vulgare L. Journal of Biological Chemistry, 274(31), 21811-21816.
5. Gnokam, F. D. S., Doubla, A., & Brisset, J. L. (2010). Temporal post-discharge reactions in plasma-chemical degradation of slaughterhouse effluents. Chemical Engineering Communications, 198(4), 483-493.

6. Hansen, P. I. E., & Mortensen, B. F. (1992). Reduction of Pollution and Reclamation of Packinghouse Waste Products. In Inedible Meat by-Products (pp. 375-407). Dordrecht: Springer Netherlands.
7. Law Yong, Ng, C. Y., Mahmoudi, E., Ong, C. B., & Mohammad, A. W. (2018). A review of the management of inflow water, wastewater and water reuse by membrane technology for a sustainable production in shrimp farming. Journal of Water Process Engineering, 23, 27-44.
8. Loehr, R. C. (1968). Pollution Implications of Animal Wastes--: A Forward Oriented Review.
9. Metcalf, W. (2003). Metcalf and Eddy wastewater engineering: treatment and reuse. Wastewater Engineering: Treatment and Reuse McGraw Hill. New York, NY, 384.
10. Mittal, G.S. (2004). "Characteristic of the Effluent Wastewater from Abattoirs for Land Application". J. Food. Rev. Int. 20(3):229-256.
11. Quinn, J. M., & McFarlane, P. N. (1989). Effects of slaughterhouse and dairy factory wastewaters on epilithon: A comparison in laboratory streams. Water Research, 23(10), 1267-1273.
12. Sangodoyin, A.Y. and Agbawhe, O.M. (1992). Environmental study on surface and groundwater pollutants from slaughterhouse effluents. Bioresource Technology 41:193-200.
13. Sathya, K., Nagarajan, K., Carlin Geor Malar, G., Rajalakshmi, S., & Raja Lakshmi, P. (2022). A comprehensive review on comparison among effluent treatment methods and modern methods of treatment of industrial wastewater effluent from different sources. Applied Water Science, 12(4), 70.
14. Schaechter, M. (2009). Encyclopedia of microbiology. Academic Press.
15. Shilton, A. (Ed.). (2006). Pond treatment technology.
16. Tritt, W.P. and Schuchardt. 1992. "Materials Flow and Possibilities of Treating Liquid and Solid Wastes from Slaughterhouses in Germany". Bioresour. Technol. 41(3): 235-245.
17. USEPA, (2004). Technical Development Document for the Final Effluent Limitations Guidelines and Standards for the Meat and Poultry Products Point Source Category (40 CFR 432) EPA-821-R-04-011. Available at: https://www.epa.gov/sites/default/files/2015-11/documents/meat-poultry-products_tdd_2004_0.pdf. Accessed on 17/02/2024.