The Slaughter House Waste Management

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Abstract: Thousands of animals are slaughtered every year in Pakistan, but unfortunately there is no proper mechanism nor waste water management system to handle the effluent discharge of the slaughtering process. Therefore, this study was designed to evaluate the potential hazards associated with slaughter houses, by analyzing wastewater characteristics and designing a suitable treatment system for safe effluent disposal. The results obtained indicate that the wastewater parameters of the slaughter house do not meet the requirements of the local effluent discharge standards. The average wastewater characteristics in terms of COD, BOD, TDS, TSS, turbidity and pH observed were 9600mg/L, 7450 mg/L, 1650 mg/L, 2280 mg/L, 1489 NTU and 6.5, respectively. The results of plain sedimentation point out that the maximum removal efficiency of COD, BOD, TDS, TSS and turbidity at 80 minutes of detention time could be obtained as13%, 21%, 10%, 30% and 39%, respectively. Out of the three coagulants tested, the alum was tested out as the most suitable coagulant in terms of its treatability performance, which gives 80% COD removal compare to lime and magnesium sulfate that gives about 56% and 71% removal, respectively. The activated system designed consists of 12m x 7.5m x 3.5m rectangular aeration tank and 12m x 7m x 5m secondary sedimentation tank. The amount of air, power and the major nutrient (N and P) required for this system were worked out as 136m3/min, 7.8kW, 152 N-kg/day and 30 P-kg/day, respectively.

Key words: slaughter house effluent, sedimentation, alum, activated sludge system, Pakistan

Introduction

Education and awareness in the area of waste and waste management is increasingly important from a global perspective of resource management. Local, regional and global air pollution; accumulation and distribution of toxic wastes; destruction and depletion of forests, soil, and water; depletion of the ozone layer and emission of "green house" gases threaten the survival of humans and other living species, the integrity of the earth and its biodiversity, the security of nations, and the heritage of future generations.

The waste hierarchy refers to the 3Rs of reduce, reuse and recycle, which classify waste management strategies according to their desirability. The 3Rs are meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

There are number of concepts about waste management which vary in their usage between countries or regions. Some of the most general, widely-used concepts include are waste hierarchy, extended producer responsibility, polluter pays principle. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator (Eckenfelder 1989).

A slaughter house is a facility where animals are killed and processed into meat foods. It acts as the starting point of the meat industry, where stock come from farms/ market to enter the food chain (Stevenson 2001). Billions of animals are slaughtered every year (Eisnitz 1997). In Pakistan there is no proper mechanized system for the slaughtering or its waste management (ETPI/Pak-EPA 1999).

Industrial wastewater treatment covers the mechanisms and processes used to treat waters that have been contaminated in some way by anthropogenic industrial or commercial activities prior to its release into the environment or its re-use. Coagulation is the addition and rapid mixing of a coagulant, the resulting destabilization of colloidal and fine suspended solids, and the initial aggregation of the destabilized particles. And in a flocculation basin, the fine microfloc begin to agglomerate into large floc particles. Particulate matters in suspension, after screening, have particle size ranging from 10.7 to 10.1 mm. Due to small size, their settling velocities (during sedimentation process) are negligible. Thus, the objective of the coagulations is to promote their settling in a short (economic) time period, by promoting particles agglomeration with the help of chemical coagulants. The three most common coagulants are; aluminum sulfate (alum), ferrous sulfate (ferric), and ferric chloride. The type of device usually used to finish the agitation required in both rapid mixing and flocculation may be mechanical (such as paddles), pneumatic, or baffle basins. The degree of mixing is based on the power imparted to the water, which is measured by the velocity gradients (Spellman, 2008).

Therefore, this study was designed to evaluate the potential hazards associated with the slaughter house by analyzing its wastewater characteristics and suggesting possible mitigation measures for its safe disposal. The study includes analysis of slaughter house effluent for major wastewater quality parameters and of its behavior using physio-chemical treatment (coagulation, flocculation and sedimentation), as well as design of a biological treatment system for the wastes studied.

	Parameter	Unit	Result	NEQS*	Remarks
1	pH	—	6.4-7.1	6-10	Permissible
2	Temperature	C°	22-26	<40	Permissible
3	Turbidity	NTU	1480-1540	—	Extremely high
4	BOD	mg/L	7200-8640	80	Beyond the limits
5	COD	mg/L	9300-1100	150	Beyond the limits
6	TDS	mg/L	1620-1685	3500	Beyond the limits
7	TSS	mg/L	2100-2180	150	Beyond the limits

* National Environmental Quality Standards

Table 1: Wastewater Characteristics of Slaughter House

Materials And Methodology

Various composite samples from a local slaughter house were collected and analyzed, using standard methods. The treatability tests were conducted using a plain sedimentation column of 12 cubic feet and, with the help of a jar test, an optimum dosage of coagulants like alum, lime, and magnesium sulfate was determined. Wastewater quality indicators like biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are essentially laboratory tests to determine whether or not a specific wastewater will have a significant adverse effect upon fish or aquatic plant life. Therefore, the samples were also analyzed for BOD and COD during the course of study, along with other wastewater parameters. There is a wide range of sampling methods that depend on the type of environment, the material being sampled and the subsequent analysis of the sample; the simplest procedure of filling a clean bottle and submitting it for conventional chemical analysis technique was adopted (APHA 1998).

Results And Discussion

The results obtained from various test conducted on a local slaughter house wastewater waster are given below in Table 1.

The results obtained from the tests indicate that the slaughter house is generating highly polluted wastes that require proper treatment before final disposal into any receiving body. For the purpose of reducing the wastewater pollution from the slaughter house, jar tests were conducted to determine the optimum dosage for their physio-chemical treatment.

In this study a comprehensive work was carried out using actual wastewater of the slaughter house on discrete sedimentation and on flocculant sedimentation. Alum, lime and magnesium sulfate were used as coagulants (Patnaik 2002).

Study on Plain Sedimentation (Discrete Settling)

As the wastewater characteristics of the slaughter house clearly indicate, most of the parameters exceed the limits of NEQS (National Environmental Quality Standards). Therefore, in our first attempt we tried to treat the wastewater in a model sedimentation tank of about 12 cubic feet. At regular intervals (20, 40, 60 and 80 minutes), the percentage removal of COD, BOD, TDS, TSS and turbidity were observed. The results obtained are shown on Table 2.

At 20 minutes and 40 minutes of detention time, the percentage removal for COD, BOD, TDS, TSS and turbidity was not very promising, but later, at the end of 60 minutes, there was a rich removal of TSS and turbidity. However, the percentage removal of COD, BOD and TDS even at the end of 60 minutes was not sufficient to follow the given guideline values set by NEQS. At the end of 80 minutes of detention times the percentage removal for COD, BOD, TDS, TSS, and turbidity observed were 13.5%, 20%, 10%, 29% and 39%, respectively. However, the observed values do not match the theoretical values of plain sedimentation treatability, which indicates that the slaughter house wastes are more dense and polluted, and contains more colloidal particles that have less settling velocities. Thus, it requires advanced or conventional treatment to bring down the various parameters to the permissible limits set by Pak-EPA NEQS. The percentages of removal of various parameters at different detention time during plain sedimentation are presented in Figure 1.

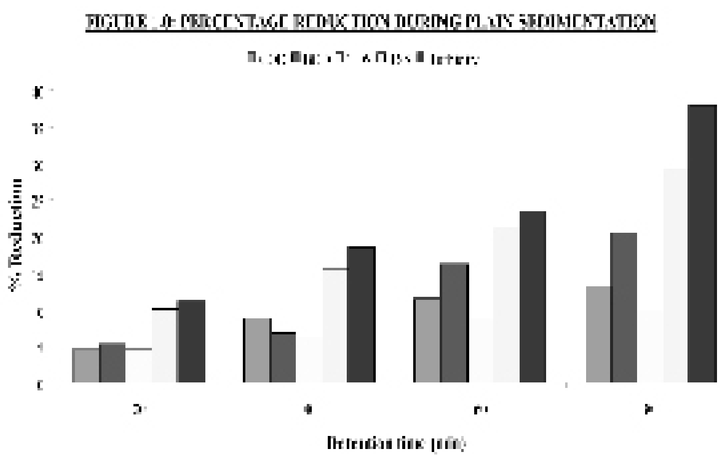
Parameter	Values	Sedimentation			
		20 min	40 min	60 min	80 min
COD mg/L	10020	9565	9142	8890	8710
BOD mg/L	6980	6605	6510	5860	5542
TDS mg/L	1575	1505	1475	1436	1420
TSS mg/L	2080	1870	1755	1640	1472
Turbidity NTU	1410	1290	1182	1110	905

Table 2. Results Obtained on Plain Sedimentation Test

Study on Using Alum Dosage

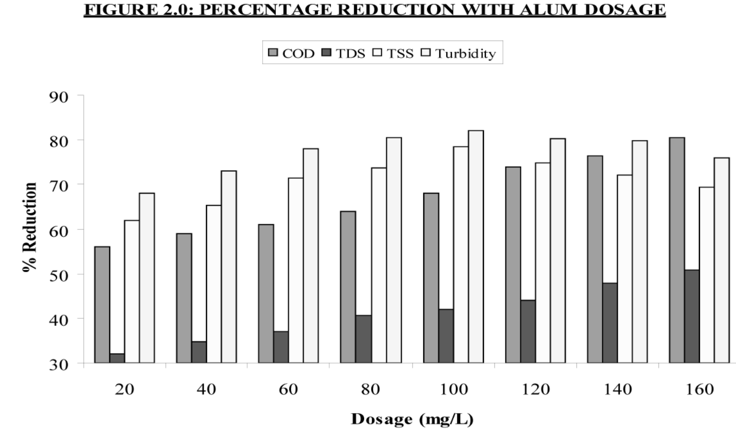
In order to determine the optimum dosage of alum coagulant, varying dosages from 20 mg/L to 160 mg/L were used during this step. The results obtained are presented in the Figure 2.

As shown in Figure 2, the optimum dosage for alum is 100 mg/L, which corresponds to 80% turbidity removal, while the COD, TDS and TSS removal corresponding to this much dosage of alum is 68%, 42% and 78.5%, respectively. The results obtained show that the percentage removal of TSS and turbidity increases with the increase in dosage concentration, until the optimum point is reached. As shown in Figure 2, by



increasing the dosage of alum beyond the optimum limits (i.e., by increasing the concentration to 120 mg/L, 140 mg/L and 160 mg/L), the treatability performance showed a decreasing trend. This indicates that beyond the optimum limits the applied amount of alum remains undissolved within the systems, thus contributing to more TSS and eventually to the turbidity.

FIGURE 2.0: PERCENTAGE REDUCTION WITH ALUM DOSAGE



Study on Using Lime Dosage

In the second step lime was used as a coagulant. In order to obtain the optimum dosage of lime, the jar test was conducted with varying lime s from 4 mg/L to 32 mg/L. The percentage removal of COD, TDS, TSS and turbidity was observed at varying dosages, as shown in Figure 3.

As shown in the figure above, the optimum dosage for alum is 20 mg/L. This corresponds to 70% turbidity removal, while the COD, TDS and TSS removal corresponding to this much dosage of alum is 56%, 30% and 66.5%, respectively. The results obtained show that the percentage removal of TSS and turbidity increases with the increase in the dosage concentration, until the optimum point is reached. As mentioned in Figure 3, by increasing the dosage of lime beyond the optimum limits (i.e., increasing the concentration to 24 mg/L, 28 mg/L and 32 mg/L), the treatability performance showed a decreasing trend. This indicates that beyond the optimum limits the applied amount of lime remains undissolved within the systems, thus contributing to more TSS and eventually to the turbidity.

Study on Using Magnesium Sulfate Dosage

In the final step, magnesium sulfate was used as a coagulant. In order to obtain the optimum dosage of magnesium sulfate, the jar test was conducted with varying magnesium sulfate dosages from 15 mg/L to 36 mg/L. The percentage removal of COD, TDS, TSS and turbidity was observed at varying dosages. The results are shown in Figure 4.

As shown in Figure 4, the optimum dosage for magnesium sulfate is 30 mg/L. This corresponds to 78% turbidity removal, while the COD, TDS and TSS removal corresponding to this much dosage of alum is 71%, 37.5% and 68.5% respectively. The results obtained that the percentage removal of TSS and turbidity increases as the increase in the dosage concentration, until the optimum point is reached. As shown in the figure, by increasing the dosage of magnesium sulfate beyond the optimum limits (i.e., by increasing the concentration to 33 mg/L and 36 mg/L), the treatability performance showed a decreasing trend. This indicates that beyond the optimum limits the applied amount of magnesium remains undissolved within the systems, thus contributing to more TSS and eventually to the turbidity and increase TSS concentration.

Selection of Optimum Coagulant

Selection of coagulant on the basis of cost comparison was carried out. Since, the optimum dosage determine by the Jar Test for alum, lime and magnesium is 100 mg/L, 20 mg/L and 30 mg/L respectively. To select the cost effective coagulant the following analysis was carried out, assuming a flow rate of 100 L/min of wastewater from a typical small scale slaughter house. See Table 3.

Although the unit cost alum is high, it gives more reliable results in terms of percentage COD removal (about 80%); therefore, for the purpose of achieving better environmental results alum is more suitable.

Wastewater Treatment System Designing

Based on the studied conducted, it has been concluded that for the treatability of slaughter house wastes, alum should be used as a coagulant and on the downstream side a conventional activated sludge process should be installed to polish the results (Masters 1998, Olivia 1980). Now using suitable design criteria an activated sludge system for a slaughter house wastewater was designed for a flow rate of 0.02m3/sec (100L/sec). The BOD concentration of slaughterhouse wastewater after 76% removal through coagulation is 1750 mg/L.

Conclusion and Recommendations

The following conclusions have been drawn working on the slaughter house wastewater;

- The effluent discharge from the slaughter house is highly polluted in terms of its physical and chemical properties.
- Most of it parameters does not meet the requirements of Pak-EPA NEQS limitations set for industrial and domestic effluent discharge
- The average wastewater characteristics of slaughter house in terms of COD, BOD, TDS, TSS, turbidity, pH is 9600 mg/L, 7450 mg/L, 1650 mg/L, 2280 mg/L, 1489 NTU and 6.5.
- Treatability of slaughter house wastewater alone in

Coagulant	Optimum Dosage (mg/L)	Unit Price (Rs/kg)	Daily Amount (kg/day)	Daily Cost (Rs/day)
Alum	100	10	14.4	144
Lime	20	8.5	2.88	25
Magnesium Sulfate	30	13	4.32	56

Table 3. Selection of Optimum Coagulant

An Aeration Tank Design

Assume t_D = 4 hours and MLVSS = 4500 mg/L

Therefore, volume of an aeration tank, V = (72 m^3/hr) * (4 hrs) = 288 m^3

Assume a depth, D = 3.5 m, therefore, surface area, A = 288/3.5 = 82.28 m^2

Say rectangular tank, L:W::1.5:1, hence, W = 7.5 m and L = 12 m

Check, volumetric loading rate, VLR = BOD applied per day/volume of the basin

As, BOD applied per day = Q*BOD = 1728 m^3/day * 1.75 kg/m^3 = 3024 kg/day

VLR = 3024 kg/day/(7.5*12*3.5) = 9.6 kg-BOD/m^3-day

Check for F/M ratio = BOD applied per day/(MLVSS*Volume of tank)

F/M ratio = 2.65/4.5 = 0.56 day^{-1}

Air required = 65 kg/kg-BOD applied, therefore, = 65*3024 = 196560 kg/day

Or air required = 136 cum/min

Power required, as 0.025 kW/m^3 of tank volume,

Therefore, power required = 0.025 * (12*7.5*3.5) = 7.85 kW

Estimation of major nutrient (nitrogen and phosphorous) requirements;

Since, N = 0.05 mg/mg BOD = 3024 * 0.05 = 152 kg/day

Similarly, P = 0.01 mg/mg BOD = 3024 * 0.01 = 30 kg/day

Secondary Sedimentation Tank Design

The required area based on average daily flow,

Area, A = (Q_{avg} / SOR_{avg}) = [1728 m^3/day]/[25 m^3/m^2/day] = 70 m^2

Similarly, Area 'A" based on peak hourly flow

Area, A = (Q_{pk} / SOR_{pk}) = [(2.5*1728) m^3/day]/[55 m^3/m^2/day] = 78.5 m^2

Since, the peak hourly flow "Q_{pk}" controls, therefore, required area A = 78.5 m^2

Assuming L:W ≈ 1.5:1

Therefore, W = 7 m and L = 12 m (Actual Area, A = 84 m^2)

Assume depth of the tank, H = 10 ft = 3.05 m

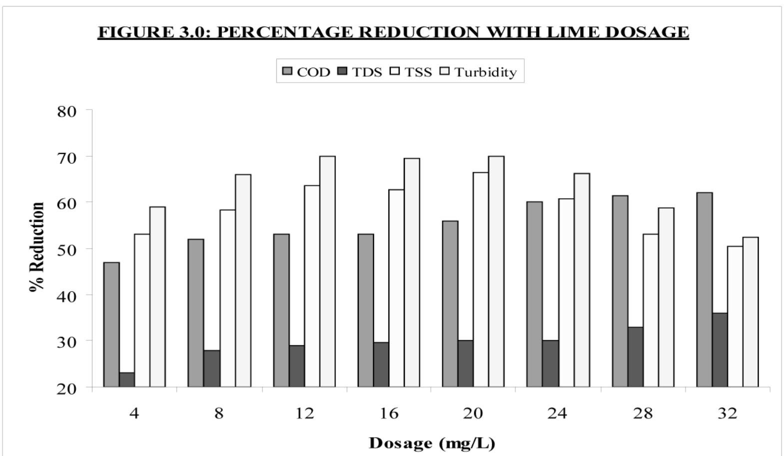
Hence, Volume of the tank, V = (Area, A) * (Depth, H) = (84*3.05) = 256.2 m^3

Check, detention time, t_D = V/Q_{pk} = (256.2)/(2.5*3) = 34.16 min

Therefore, total depth, D = 3.05 + 1.5 + free board = 5.0 m

Aeration Tank	
Dimensions, L x W x D	12m x 7.5m x 4.0m
Air required	136 m^3/min
Power required	7.8 kW
F/M ratio	0.56 day^{-1}
MLVSS	4500 mg/L
Nutrient requirements	N = 152 kg/day, P = 30 kg/day
Secondary Sedimentation Tank	
Dimensions, L x W x D	12m x 7m x 5.0m

Table 4. Summary of Designing



Plain Sedimentation seems to be non-feasible, as it does not give the required efficiency in terms of COD/BOD/TSS etc removal.

- The maximum COD, BOD, TDS, TSS and turbidity removal at 80 minutes of detention time is 13%, 21%, 10%, 30% and 39%, respectively.
- Out of the three coagulants, namely alum, lime and magnesium sulfate, tested using the Jar Test apparatus, alum is considered to be most suitable in terms of treatability performance that gives 80% of COD removal. Whereas, the lime and Magnesium sulfate gives about 56% and 71% removal, respectively.
- The total cost for using alum as a coagulant is about 144 Rs/day for an average flow of 100 liters per minute
- Installation of an activated sludge system will give better and polish results in term of treatability. A rectangular aeration tank of 12m x 7.5m x 3.5 m is required.
- The amount of air and power required for aeration tank is estimate to be 136 cum/min and 7.8 kW, respectively; whereas, the major nutrient (N and P) requirement is sorted out as 152 N-kg/day and 30 P-kg/day.
- The designed dimensions of a secondary sedimentation tank are 12m x 7m x 5.0.

The following recommendations have been proposed:

- More studies should be conducted on the slaughter house wastewater to evaluate its composting and bio-gas generation efficiency using biological treatment procedures.
- The alum dosage should be studied under various operational conditions in detail, like varying the pH, temperature, etc.
- For agitation during rapid-mixing and slow-mixing, variability of treatment should be studies for various agitator like turbine, paddles etc.
- There should be a detail study on the physio-chemical sludge obtained during sedimentation process, and on the biological sludge obtained from activated sludge system while treating a slaughterhouse wastewater.
- Various other types of coagulants may also be tried, using actual wastewater of the slaughter house.

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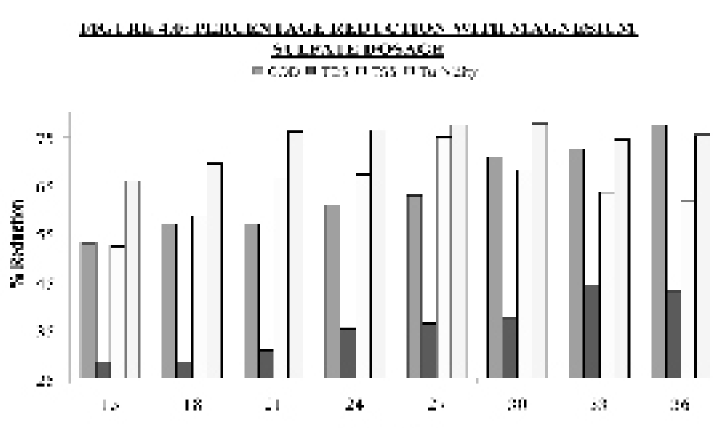

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NATIONAL NEWS

Regional Center of Excellence in Micro Hydro Electricity Generation Launched

April 19, 2010, marked the launch of the Regional Centre of Excellence in Micro Hydro (RCEMH) in Kathmandu, Nepal. This center is the only institution in South Asia dedicated to promoting micro hydro electricity generation. An initiative of the USAID's South Asia Regional Initiative for Energy (SARI/E) program, this Center was launched in cooperation with the Alternative Energy Promotion Centre (AEPC), Ministry of Environment in Nepal. RCEMH will build on Nepal's extensive track record in micro hydro project development. This center will help expand clean energy opportunities in the South Asia region by offering project development support, training, and best practice information to stakeholders in micro hydro development throughout the region.

Shares may be called in Construction phase of Infrastructure projects

In infrastructure sector including Hydropower, legal hurdles have been removed to allow investment. The Security Board has made amendment to allow call of Initial Public Offering (IPO) while establishing a company. This has widened the scope of local investment in the projects.

Securities Registration and Share Issue Regulation has been amended allowing collection of shares in the beginning for infrastructure projects such as Hydropower, cement, mineral industries etc. As per Mr. Surbeer Poudel, Chairperson of the Securities Board, the infrastructural project require 5-7 years for construction and needs money in the beginning; hence, shares issue has been permitted. Previously, share were allowed to be issued only after 2 years of company operation. Unlike in Banking sector, Hydro sector needs money in the beginning not at a later stage. This is a good initiative to attract investment in the hydropower sector to alleviate load shedding. Mr. Gyanendra Lal Pradhan is of the opinion that it is a welcome step, but needs good monitoring stating that one may collect money from the public and then vanish.

As local resources are used in the project operation, there is a provision for allowing up to 10% shares for the locals near the project. Further, only 15% public shares can be called from general public; previously it was mandatory to issue 30% shares to the public.

5000 Households to Receive Solar

ACE Development Bank, Nepal in Association with Winrock International will undertake responsibility of financial intermediary in Distribution of Solar lighting Systems in 5000 households of remote areas of 14 districts of Nepal. The Bank is trying to extend facilities in remote area where there is no electricity service under support from Sustainable Energy & Climate Investment of UN Environment Programme and financial support from Frankfurt Financial & Management School of Germany. The assistance is worth US$1.8 Million.