TREATMENT OF SLAUGHTERHOUSE WASTEWATER

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Abstract - A thorough review of advancement in slaughterhouse wastewater characteristics, treatment of wastewater in the meat processing industry is presented. This study also provides a general review of the environmental impacts, health effects, and regulatory frameworks relevant to the slaughterhouse wastewater management. Slaughterhouse wastewater contains various and high amounts of organic matter (e.g., proteins, blood, fat and lard). In order to produce an effluent suitable for stream discharge, sedimentation, chemical coagulation & filtration techniques have been particularly explored at the laboratory pilot scale for organic compounds removal from slaughterhouse effluent. The purpose of this work was to investigate the feasibility of treating cattle-slaughterhouse wastewater by sedimentation, chemical coagulation & filtration. The rate of removal of pollutants linearly increased with increasing doses of PaCl. COD and BOD_5 removal of more than 79%, 84%, and 90% was obtained by adding 100 mg/L PaCl. The experiments demonstrated the effectiveness of techniques used for the treatment of slaughterhouse wastewaters. This review also facilitates a better understanding of current difficulties that can be found during management of the SWW, including treatment and characteristics of the final effluent.

Keywords: Coagulation, sedimentation, filtration, slaughterhouse wastewater (SWW), treatment

I. INTRODUCTION

The increasing growth of world population has augmented the pollution of freshwater due to the inadequate discharge of waste- water, especially in developing countries (Gopala Krishna 2009). For this reason, water and wastewater treatment has become crucial for the continuing development of the society. Moreover, the progressively stricter standards for effluent discharge worldwide have made the developing of advanced wastewater treatment technologies necessary (US EPA, 2004; World Bank Group, 2007).Besides, the continuing decreasing availability of freshwater resources has rearranged the objectives in the wastewater treatment field from disposal to reuse and recycling. As a result, a high level of treatment efficiency has to be achieved. Given the differences in location, economic resources, living standards of different countries, and characteristics of water and its pollutants, many nations adopt diverse techniques for water and wastewater treatment (Daigger, 2009).Wastewater from a cattle slaughterhouse is a mixture of the processing water from both the slaughtering line and the cleaning of the guts, which causes a large variation in the concentration of organic matter. The main pollutant in slaughterhouse effluents is organic matter. The contributors of organic load to these effluents are paunch, feces, fat and lard, grease, undigested food, blood, suspended material, urine, loose meat, soluble proteins, excrement, manure, grit and colloidal particles. Untreated slaughterhouses waste entering into a municipal sewage purification system may create severe problems, due to the very high concentration of BOD & COD. Therefore treating of slaughterhouse wastewater is very important for prevention of high organic loading to municipal wastewater treatment plants. The most common methods used for treating slaughterhouse wastewaters are fine screening, sedimentation, coagulation– flocculation, trickling filters and activated sludge processes. Sedimentation, filtration and chemical coagulation using PaCl was carried out in this study for the treatment of slaughterhouse wastewater. Chemical coagulation of slaughterhouse wastewater has also been studied by adding aluminum salts and polymer compounds, and a maximum COD removal efficiency of 75% has been reported. Poly aluminum chloride (PaCl) is commonly used as the flocculants to coagulate small particles into larger flocs that can be efficiently removed in the subsequent separation process of sedimentation and/or filtration. Much attention has been paid to PaCl in recent years because of its higher efficiency and relatively low costs compared with the traditional flocculants. On the other hand, PaCl has become one of the most effective coagulant agents in water and wastewater treatment facilities with various applications, including removal of colloids and Sedimentation, filtration and Chemical coagulation using Pacl of wastewater from a cattle slaughterhouse is described in this article.

II. CHARACTERSTICS OF SLAUGHTERHOUSE WASTEWATER

Slaughter houses require fresh and potable water for almost all washing and rinsing operations. Water consumption details for slaughtering of large and small animal is shown in the following Table 1. All water used in slaughter is generated as wastewater. Quantity of water required is more in the case of mechanized system as compared to manual slaughtering. The water consumption also varies depending on the size of the slaughter house i.e. large slaughter house require less water when compared to small slaughter houses for large animals. However, the water requirement does not much vary in slaughterhouses for small animals

Table 1 Water consumption details for slaughterhouse (No. IPC-IV/Project-SH/2017-18)

S N	Animal	Category	Specific water consumption M^3/TLWK
1	Buffalo	Large	0.3-0.5
		Medium	0.1-0.25
		Small	0.05-.25
2	Goat/Sheep	Large	1.2-2.1
		Medium	1.3-2.5
		Small	0.8-1.7

Typical characteristics of slaughter house wastewater are given in Table 2. Wastewater discharged from slaughterhouse contains high BOD, COD and TSS concentrations and treated fully or partially in effluent treatment plant depending upon the location, capacity and type of slaughterhouses and the treated effluent is disposed into sewer system.

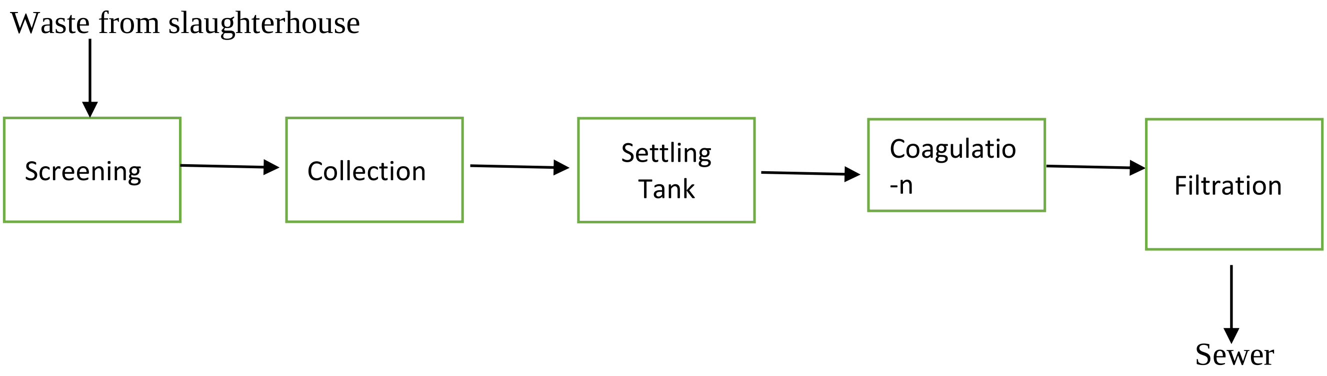
Table 2 Typical characteristics of slaughterhouse wastewater

S N	Parameter	Raw effluent
1	pH	7.6-8.2
2	Total suspended solids (mg/l)	1500-4500
3	Biochemical Oxygen Demand (mg/l)	1200-4000
4	Chemical Oxygen Demand (mg/l)	3000-7000

III. AIMS AND METHODOLOGY

Aim of the study is to reduce the effluent from wastewater, in order to obtain desired aim various parameters (BOD, COD, TSS, and pH) were analyzed in laboratory using:-

1. Settling the slaughterhouse wastewater for 24 hour in preliminary settling tank before filtration and coagulation to evaluate the effect on BOD, COD, TSS, pH removals on the first 24 h in laboratory.
2. Coagulate the wastewater using PaCl as coagulant to investigate the effect of coagulation process in the removal efficiencies of BOD, COD, TSS, and pH.
3. Designing the Low-cost sand filter model and treatment of sample by filtration process using low-cost natural adsorbents and study the performance of multimedia filter with different packing media.



IV. EXPERIMENTAL WORK

A.SEDIMENTATION

Sedimentation is a physical water treatment process used to settle out suspended solids in water under the influence of gravity. Basics Suspended solids (or SS), is the mass of dry solids retained by a filter of a given porosity related to the volume of the water sample. This includes particles of a size not lower than 10µm. Colloids are particles of a size between 0.001 nm and 1 nm depending on the method of quantification. Due to electrostatic forces balancing the gravity, they are not likely to settle naturally. The limit sedimentation velocity of a particle is its theoretical descending speed in clear and still water. In settling process theory, a particle will settle only if

1. In a vertical ascending flow, the ascending water velocity is lower than the limit sedimentation velocity.
2. In a longitudinal flow, the ratio of the length of the tank to the height of the tank is higher than the ratio of the water velocity to the limit sedimentation velocity.

There are four types of sedimentation processes:

1. Type 1 - Dilutes, non-flocculent, free-settling. (Every particle settles independently.)
2. Type 2 - Dilute, flocculent. (Particles can flocculate as they settle.)
3. Type 3 - Concentrated Suspensions, Zone Settling (Sludge Thickening).
4. Type 4 - Concentrated Suspensions, Compression (Sludge Thickening).

APPLICATIONS

A. Potable Water Treatment

Sedimentation in potable water treatment generally follows a step of chemical coagulation and flocculation, which allows grouping particles together into flocs of a bigger size. This increases the settling speed of suspended solids and allows settling colloids.

B. Waste Water Treatment

Sedimentation is often used as a primary stage in modern waste water treatment plant, reducing the content of suspended solids as well as the pollutant embedded in the suspended solids. Due to the large amount of reagent necessary to treat domestic wastewater, preliminary chemical coagulation and flocculation are generally not used, remaining suspended solids being reduced by following stages of the system. However, coagulation and flocculation can be used for building a compact treatment plant (also called a "package treatment plant"), or for further polishing of the treated water. In the Activated Sludge treatment process, flocs being created through biological activity are collected in sedimentation tanks, generally referred to as Secondary Clarifiers or Secondary Sedimentation Tanks.

EFFECT OF PRELIMINARY SETTLING

Preliminary settling process is a natural treatment method that requires no chemical addition. Although some workers realized the importance of the natural settling process, there is little information available in the literature on the effect of the preliminary settling time on TSS removal capacity. Most studies carried out on the treatment of slaughterhouse wastewater were based on diluted pre-settled wastewater. In this study, the raw slaughterhouse wastewater was allowed to settle for 24 h in a preliminary settling tank before coagulation and filtration. The process had an effect on BOD_5, COD, TSS, removals on the first 24 h. COD concentration reduced up to 22% whereas BOD_5 was reduced up to 20 .Furthermore, TSS concentration was reduced up to 55%.

A. Laboratory test

After **k**eeping the sample for 24 hours for its sedimentation following are the perimeters tested in laboratory.

Table 3. Evaluated parameters of slaughterhouse wastewater before & after its sedimentation.

S.no.	Parameters	Units	Raw water	settled wastewater after 24 hours	% removal
1	BOD	mg/l	2127	1688	20.63
2	COD	mg/l	4321	3328	22.98
5	TSS	mg/l	2376	1007	57.61
6	pH		7.2	7.4	

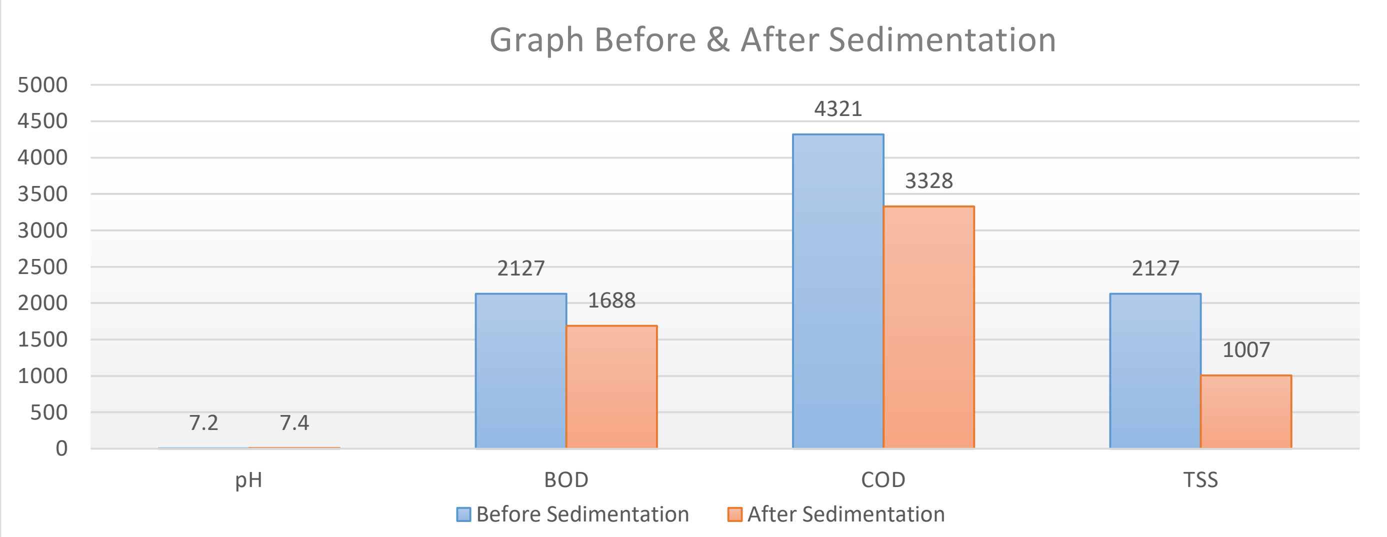


Figure 1 Graph before and after wastewater sedimentation

B. COAGULATION

Chemical coagulation is a unit process for the removal of colloidal solids from solution. The process consists of the addition of chemicals as slurries, solutions or in the dry form; a rapid mix to quickly disperse the chemicals throughout the solution; flocculation or a slow agitation period to permit floc growth and agglomeration of particles; and separation of solids and liquid phases.

The chemicals normally added consist of:

1. A coagulant -- usually the salts of a trivalent metal such as iron and aluminum.

2. A control chemical for pH and alkalinity -- usually lime.

3. A coagulant aid such as activated silica or a polyelectrolyte.

The type, amount, order and point in the process at which the chemical additions are made are important and are best determined by field measurements. The aim of chemical treatment is to provide a desired quality effluent at the required plant capacity with the most economical overall operation. Too little chemical addition will not provide the desired quality. Overfeed of chemicals is a waste -- may result in interference with filtration and may result in undesirable chemical residuals in the plant effluent. If the sludge's are to be separately digested, the effect of certain chemical additions must be carefully evaluated. After sedimentation, coagulation of collected wastewater sample using Pacl was carried out in laboratory.

Coagulation of collected slaughterhouse waste water sample

Coagulation experiments using PaCl as coagulant in the jar test were performed to investigate the effect of coagulation process in the removal efficiencies of COD, BOD_5, and TSS. Therefore, PaCl was added to the slaughterhouse wastewater to achieve particle instability and increase in the particle size, consequently achieving effective removal of organic substances present as COD and BOD_5. The doses of PaCl as coagulant were varied between 0 and 100 mg/L to determine the optimum dose of PaCl for pollutants removal. It is shown that at lower doses of the PaCl (25 mg/L), COD, BOD_5, and TSS removal efficiency reached a maximum of 37%, 33%, and 60%. The efficiency of the process increased with increasing dosages of coagulant (PaCl). The curve obtained with PaCl points to a considerable increase in performance from the lowest dose up to 100 mg/L. On the other hand in chemical coagulation, an increase in COD, BOD_5, TSS, and other pollutants removal efficiency is noted with increasing PaCl dosage, reaching nearly 60–80% for PaCl dosage of 100 mg/L. All the chemicals used in the study were of analytical reagent (AR) grade. Poly-aluminum chloride (PaCl) was chosen for this study because it has been used extensively at water and wastewater treatment plants to remove solids and may function as an effective and less expensive coagulant. PaCl was used in this study up to 100 mg/L (50, and 100 mg/L). A six-beaker jar test (flocculator) was set up at room temperature for each trial. Each of the beakers contained 1 L of settled wastewater. The coagulants were added into the beakers. Rapid stirring at 150 rpm for 2 min was followed by gentle mixing at 50 rpm for 20 min, and the solids formed were left to settle for 30 min.

Laboratory tests results

Following are the parameters recorded after applying 25, 50, 75 & 100mg/l Dosage of PACl to wastewater in laboratory

Table 4 Parameters of slaughterhouse wastewater after its coagulation.

Parameters/dosage (mg/l)	**0**	**25**	**50**	**75**	**100**	**% removal on 100 mg/l**
BOD	1688	1324	1118	980	709	57.99
COD	3328	2876	2133	1740	1120	66.34
TSS	1007	898	565	320	289	71.3
pH	7.4	7.4	7.3	7.4	7.6	

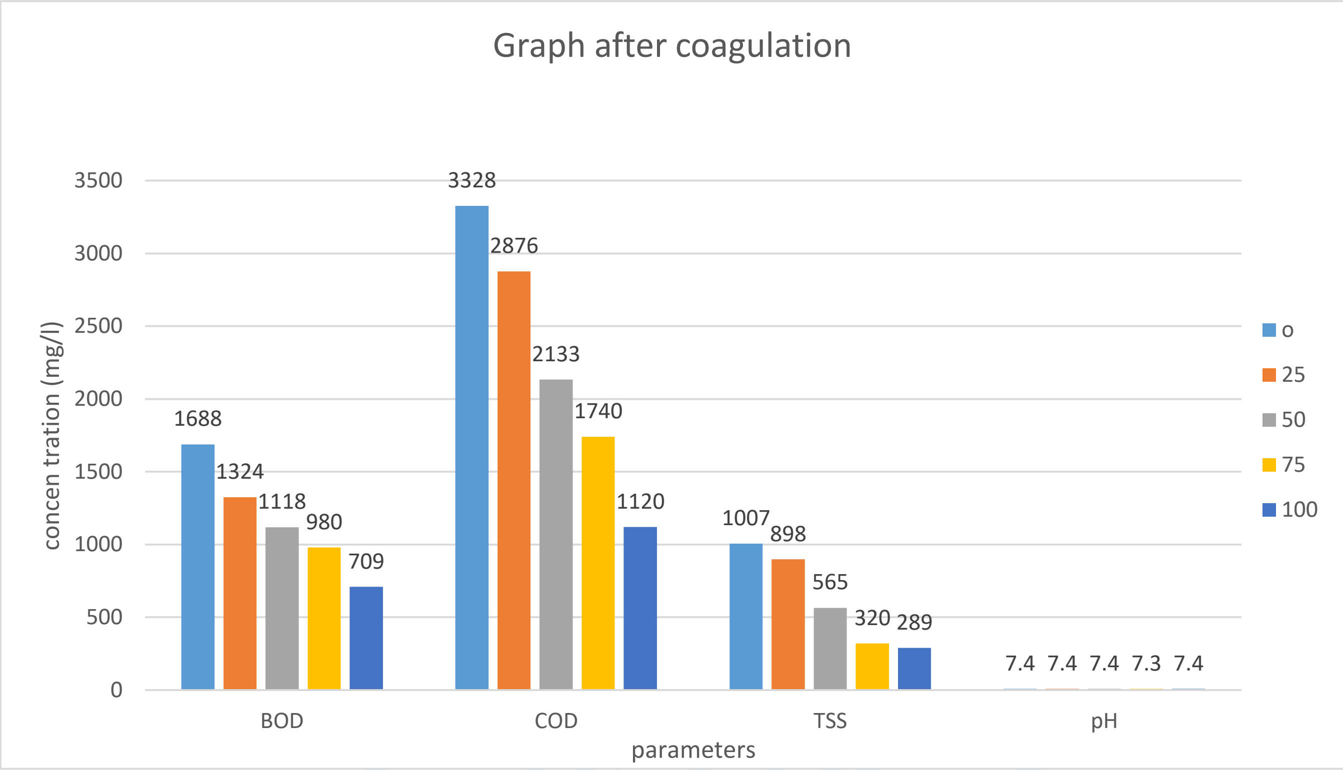


Figure 2 Graph after coagulation

C. FILTRATION

Filtration is any of various mechanical, physical or biological operations that separate solids from fluids (liquids or gases) by adding a medium through which only the fluid can pass. The fluid that passes through is called the filtrate. In physical filters oversize solids in the fluid are retained and in biological filters particulates are trapped and ingested and metabolites are retained and removed. However, the separation is not complete; solids will be contaminated with some fluid and filtrate will contain fine particles. Filtration occurs both in nature &in engineered systems, filtration removes wastes from the blood & in water treatment & sewage treatment undesirable constituents are removed by absorption into a biological film grown on or in the filter medium, as in slow sand filtration

Following are the types of Sand Filter

1. Slow Sand Filters
2. Rapid Sand Filters
3. Roughing Filters

Slow Sand Filters

Slow sand filters use sand with effective sizes of 0.15 - 0.35 mm (see section 3) to remove a large percentage of coliforms, cryptosporidium and Giardia cysts. They operate most effectively at a flow rate of 0.1 – 0.3 m/h (or $m^3/h/m^2$), which equates to 100 – 300 l/h per m 2 of filter area. These filters use physical processes such as sedimentation, adsorption and straining to remove fine particles as well as microbiological processes to remove organic material and bacteria. Because of the slow filter rates the raw water sits above the sand for several hours before passing through it, various oxidation reactions break down organic material during this time. Algae, that grows on the sand surface, consumes this oxidized organic material and releases oxygen back into the water. Roughing filters and sedimentation are often used as pre-treatments to reduce the turbidity of the raw water and therefore reduce the rate at which the slow sand filter becomes clogged. Some aeration, to increase the oxygen content of the raw water, is also desirable. Post-filtration chlorination or UV-purification can also be used; however, with a filter that is functioning well such treatments are not strictly necessary.

Table 5 General design criteria for slow sand filters as per IS 11401 (part-2):1990

SN	Design Criteria	Recommended value
1	Design period	15-30 years
2	Period of operation	24 hours
3	Water Demand	40 liter per capita per day
4	Filtration Rate	0.1-0.2 m/h
5	Filter bed area	200 m^3 per filter
6	Depth of filter sand a) Initial b) Minimum Specification of sand a) effective size b) Uniformity coefficient	 0.8-0.9 m 0.5-0.6 m 0.15-0.30 mm Max 5
7	Height of underdrain including gravel layer	0.3-0.5 m
8	Height of supernatant water	1 m

Calculated dimensions of filter model as per IS 11401 (part-2):1990

Assuming the flow rate as .09 $m^3/m^2/h$ then

1. Height = 500 mm
2. Width = 250 mm
3. Material = glass of 8 mm thickness
4. Fine Sand = 1.8mm with depth 60 mm
5. Material 2 = aggregates of size 6.3mm with depth of 60 mm.
6. Material 3 = aggregates of size 16mm with depth of 130 mm.

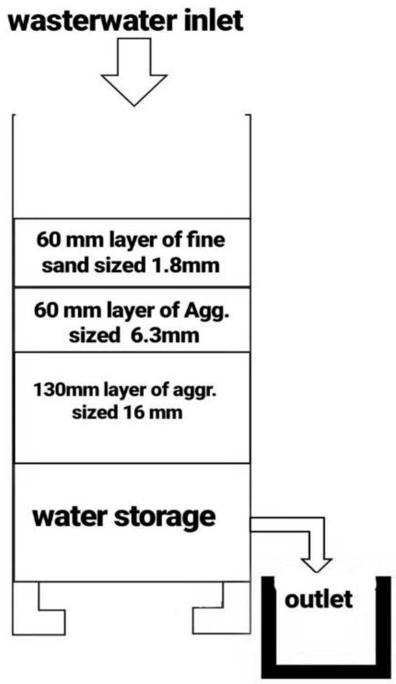


Figure 3 Design of Slow sand filter

Analysis and working of model

1. The adsorbent material and sand was properly fitted in the chamber of filter model.
2. The sand layer was laid on the top of filter chamber.
3. The wastewater from inlet tank enters the inlet chambers and flows in sequence i.e. down flow regime.
4. After reaching the outlet level the treated effluent was collected in the outlet tank for the analysis of treated sample in laboratory.
5. The treated water have been analyzed in laboratory.
6. Following are the parameters (BOD, COD, TSS, and pH) which were analyzed in laboratory.

Analysis of sample carried out in laboratory after filtration

The parameters which were evaluated in laboratory after the filtration of collected wastewater sample are BOD, COD, TSS, and pH, as shown in table

Table 6 Parameters of slaughterhouse wastewater after its filtration.

S.no.	Parameters	Units	Before filtration	After filtration	% Removal
1	BOD	mg/l	709	443	37.51
2	COD	mg/l	1120	691	38.3
5	TSS	mg/l	289	126	56.4
6	pH		7.4	7.2	2.7

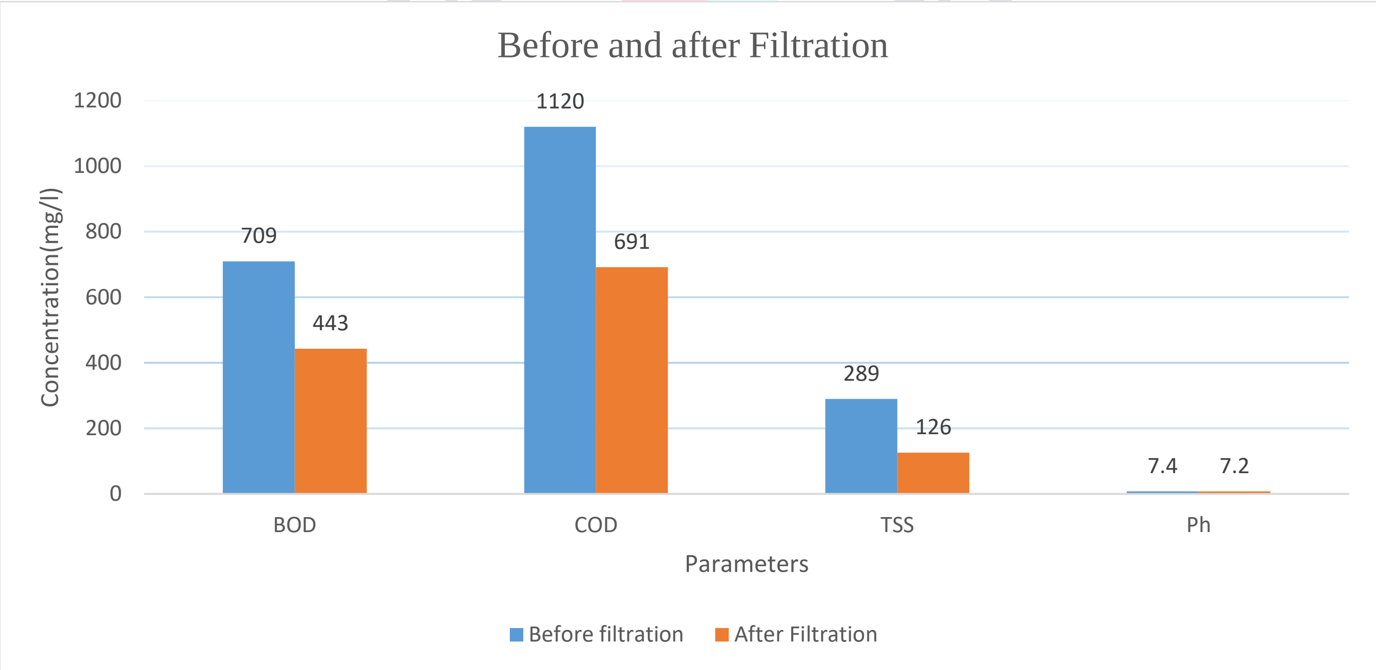


Figure 4 Graph before & after filtration

V. RESULTS

It was observed that the sedimentation process had major effect on BOD_5, COD. TSS concentration was reduced approximately up to 20%, 23% & 57%.The effect of coagulation process by using PaCl 100 mg/l as coagulant in the removal efficiencies of COD, BOD_5 was decreased approx. 57%,66%& 71%., TSS. It was observed that efficiency of coagulation was increased with increase in dose of PaCl. 100 mg/l of PaCl was the optimum level of dose. In filtration those adsorbent prove to be more efficient in improving the effluent quality in terms of its physio-chemical content. It was also observed that the experimental filter model will significantly assist in the removal of BOD, COD, and TSS. Using designed filters BOD_5, COD. TSS concentration was reduced approximately up to 37%, 38% & 57% from initial before sedimentation and after filtration BOD_5, COD. TSS concentration was reduced approximately up to 78%, 80% & 90%. Hence, the results of present investigation that this method will be found to be an effective at very low cost for the removal of impurities from slaughterhouse waste water.

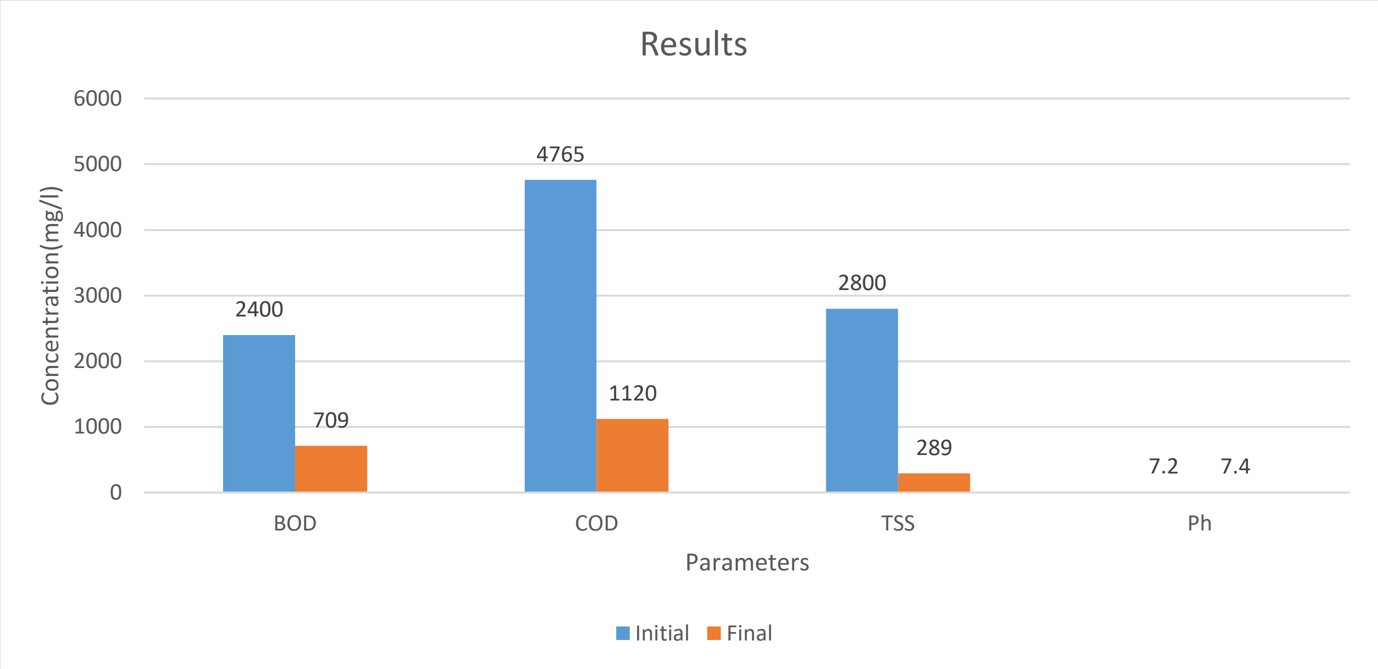


Figure 5 comparison of initial (before treatment) and Final parameters (after treatment)

VI. CONCLUSION

The study revealed that this sedimentation, coagulation and filtration method will performed well for the future need and has less cost of production and maintenance. This project will help to understand a new approach of an environmental friendly low cost slaughterhouse wastewater technique which can be used commonly in the every slaughterhouse. Hence, this technology is environment friendly and cost effective. Based on the results of this study, it can be concluded that filter material have good performance to adsorb effluent from polluted water especially for high concentration of pollutant and the Multimedia Filter process had given an excellent results and significantly assist in the removal of pH, BOD, COD, TSS, and will improve the physio-chemical quality of the effluent. It can also be concluded from the study that the Multi – Media filter may be considered as efficient pretreatment process for wastewater treatment. Also, the above media may enhance the performance of the treatment system. Instead of meeting the effluent discharging standards, aim was to reduce the load on nearby treatment plant before releasing the wastewater into inland surface water. Hence, thus achieved by reducing BOD, COD, TSS approximately 75%, 80% and 90%.

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