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Slaughterhouses Wastewater Characteristics in the Gaza Strip

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Abstract

Slaughterhouses generate considerable quantities of wastewater due to the huge amount of blood produced from slaughtering process and the need for cleaning and hygiene of meat. Due to the extraordinary content of organics and minerals, wastewater from slaughterhouses needs special care and treatment for safe disposal to the environment. Currently, wastewater from slaughterhouses in the Gaza Strip is discharged to the public networks without any treatment burdened central wastewater treatment plant, where partially treated effluent discharged to the sea. The aim of this research is to characterize the wastewater from Gaza slaughterhouse to identify the best approach for treatment. Samples from the slaughterhouse were collected during working hours and analysed for physical and chemical parameters. The pH, EC, DO, BOD, TSS, COD, Ammonia Nitrogen and TKN account for 7.1, 3300 µsm, 1.95, 2350, 3500, 4502, 30 and 154 mg/l, respectively. Wastewater from Gaza city slaughterhouse is within the range in comparison to other wastewater from slaughterhouses all over the world.

Keywords

Slaughterhouse, Gaza City, Chemical and Biological Oxygen Demand, Total Nitrogen, Total Suspended Solids

1. Introduction

The endless effort to produce meat for the protein needs of the ever-increasing population of the Gaza Strip as a densely-populated area with a total population of approximately 2 million [1] has some pollution problems involved. Currently, the annual average slaughtered livestock in the Gaza Strip is 33868. Therefore, the per capita share of meat annually is accounted for 6.23 kg.

The Gaza Strip has been suffering from serious infrastructure challenges in

wastewater collection/disposal and treatment. For hygienic purposes slaughterhouses, use a large amount of water in slaughtering and cleaning, which generate a high amount of wastewater in all over the world. The yearly domestic and industrial wastewater generation within the Gaza Strip reaches approximately 40 Million Cubic meters [2] [3]. Most of Gaza Strip slaughterhouses are directly connected to the public sewerage networks with insignificant primary treatment on site. Slaughterhouses wastewater contaminate groundwater due to the high content of blood, fat, manure, urine, and meat tissues are lost to the wastewater public networks then to overloaded wastewater treatment plants. Accordingly, the effluent generated is usually with poor quality that is not compliant with the WHO/ Palestinian standards for groundwater recharge and reuse [4]. Slaughterhouse wastewater infiltration into groundwater is a main measure of apprehension, specifically due to the blood as one of the major dissolved pollutants in wastewater. Additionally, slaughterhouse wastewater is recognized as one of the most polluted industrial wastewaters by US-EPA because the inadequate treatment of effluent leads to groundwater pollution [5]. The blood from a single slaughtered cow is equivalent to the effluent load of the total sewage produced by 50 people on average day [6]. Therefore, slaughterhouses effluent should be treated sufficiently for safe disposal as an economic and public health necessity [7]. The coastal aquifer is the main and merely water supply source for domestic use and production sectors such as agriculture and industry in the Gaza Strip. The quality and quantity of the coastal aquifer have been deteriorated due to low recharge as a result of increased in the runoff which led to a decrease in the infiltrated quantity to the aquifer [8] [9] Abu [10]. The nitrate ion concentration reaches a very high level in various areas of the Gaza Strip, while the WHO standard recommended nitrate concentration less than 50 mg/L for drinking purposes. Samples from municipal wells showed that NO_3 concentration is ranging between 50 mg/l and 300 mg/l. The high NO_3 concentration is noticed in residential areas of Gaza Strip indicating the infiltration of the wastewater to the coastal aquifer through the leakage from wastewater collection networks or cesspits and septic tanks from residential communities which have not sewerage systems [11]. In the research, the slaughterhouses wastewater characteristics will be studied. Accordingly, to propose the efficient treatment system based upon the overview of worldwide slaughterhouses wastewater characteristics to prevent any further pollution to the groundwater.

2. Study Area and Methodology

Eight influent samples have been collected before the suspended solid separator in the onsite wastewater treatment plant during the working hours. The total slaughtered calves on that day are 260 head. Samples were stored at 4˚C in containers in the lab for analysis.

Samples Analysis

The collected samples from the inlet of the aerated lagoon were examined for;

Electrical Conductivity (EC) to explore the salinity of the wastewater, the acidity (pH), total suspended solids (TSS), biological oxygen demand (BOD), Chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), Orthophosphate (PO_4) and ammonium (NH_4). All tests were conducted following the Standard Method for the testing of water and wastewater [12].

The acidity (pH): The combined portable meter (Type HI 8424) was used for testing after the calibration of the instrument at pH 4 and 7 by the calibration solution of pH 4 and 7.

Electrical conductivity (EC): The same samples were measured for the EC by using EC meter (Type El-Hanna, TH-2400).

Biochemical Oxygen Demand (BOD): The samples were incubated for 5 days at 20˚C by using OxiTop measuring system, and the samples were filled in the OxiTop bottles after well mixing and diluted to matching test range as recommended by the manufacturer manual.

The chemical oxygen demand (COD): Due to the complex content of the slaughterhouses wastewater and the existence of uneasy biodegradable organic matter, COD is tested to determine the total oxygen demanded to oxidize the complex organic matter content of a sample by strong oxidants ($K_2Cr_2O_7^2$ /H_2SO_4 at 145˚C). Spectrophotometer is used to determine the oxidant used to oxidize the organic matter in the tested samples.

The total Kjeldahl nitrogen (TKN): It consists of Ammonia/Ammonium and the organic nitrogen. The samples were digested in Kjeldahl apparatus using sulfuric acid (H_2SO_4), potassium sulfate (K_2SO_4), and copper Sulfate ($CuSO_4$) as a catalyst.

Suspended Solid (SS): A homogeneous samples are filtered through known weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight 105˚C. Then the difference in the weight of the filter and the filter with the remaining solids is defined as the suspended solids according to 2540 D method [13].

Ammonia (NH_4): Ammonia in wastewater was determined according to Kjeldahl methods without digestion in this procedure, and distillation method was used followed by titration step to determine the concentration of ammonia. NaOH solution was added to wastewater sample and ammonia distilled into a solution of boric acid. The ammonia in the distillate was determined titrimetrically with standard HCl [12].

3. Results and Discussion

3.1. Gaza Slaughterhouse Veterinary Services

Gaza Strip has two central slaughterhouses; for Gaza Municipality and khan Yunes Municipality, in addition to many private slaughterhouses and private slaughterhouses for chickens. The daily capacity of the Gaza city slaughterhouse is 190 heads of calf and 300 heads of sheep and goats. Sewage treatment plant is attached to the slaughterhouse equipped with suspended solid separator and ae-

rated lagoon as onsite treatment before disposal to Gaza central wastewater treatment plant. Due to the lack of energy supply, the aerators are malfunctioning and the lagoon is used as storage pond before evacuation to the public network.

3.2. Water Consumption and Wastewater Production

Water is required for many purposes in the Slaughterhouse, the cleaning process consumes the highest amount 75 m^3/day, while it requires around 50 m^3/day for both slaughtered animals cleaning and cleaning of the slaughterhouse giving the total amount of 100 m^3/day. While the daily wastewater generation is accounted for 66 m^3 divided between cleaning process 50 m^3 and paunch cleaning 15 m^3 mixed with one cubic meter of blood as shown in Table 1. In the Gaza slaughterhouse the average slaughtered heads per day is 35, therefore the per head is accounted for 2.8 m^3. The water consumption per slaughtered animal various according to the animal and the cleaning process, and ranges from 0.3 to 4.1 m^3 per slaughtered animal [14].

3.3. Gaza Slaughterhouses Wastewater Characterization

Slaughterhouse wastewater is considered unsafe worldwide due to its composition of fats, proteins, fibers, high organic content, pathogens, and pharmaceuticals for veterinary purposes. As shown in Table 2, the effluent from Gaza Slaughterhouse was characterized in terms of pH (7.1 ± 0.1), electrical conductivity (3300 ± 500 μs/m), dissolved Oxygen, BOD, TSS, COD, Ammonia nitrogen and total Kejeldhal Nitrogen and Orthophosphate accounted for 1.95 ± 0.30, 2350 ± 100, 3500 ± 120, 4502.5 ± 170, 30 ± 7, 154 ± 12 and 9 ± 4 mg/l, respectively. The pollution main source of wastewater in slaughterhouse is the high quantity of blood [15]. Therefore an effective treatment system is essential to remove the high blood content of organic matter to fulfill with the requirements and standards proven by environmental legislation to prevent the ecosystem. The pollution load of meat-processing and slaughterhouses has been estimated at over 1 million population equivalent in the Netherlands [16], and 3 million in France [17], while the pollution load of Gaza city slaughterhouse has been estimated at population equivalent 3231. Blood, one of the major dissolved pollutants in slaughterhouse wastewater, has a chemical oxygen demand (COD) of 375,000 mg/l [14]. Slaughterhouse wastewater also encloses high concentrations

Table 1. Daily water consumption and wastewater generation in the Gaza slaughterhouse.

Type of consumption	Water consumption m^3/day	Wastewater generation m^3/day
Paunch cleaning water	15	15
Cleaning process water	75	50
Garden irrigation	10	0
Blood	0	1
Total	100	66

Table 2. Effluent wastewater parameters of the Gaza slaughterhouse.

Type of consumption	Water consumption m3/day	Wastewater generation m^3/day
Paunch cleaning water	15	15
Cleaning process water	75	50
Garden irrigation	10	0
Blood	0	1
Total	100	66

of suspended solids (SS), including pieces of fat, hair, feathers, grease, flesh, grit, manure, and undigested feed. These insoluble and slowly biodegradable suspended solids represent 50% of the pollution charge in screened (1 mm) slaughterhouse wastewater, while another 25% originated from colloidal solids. Slaughterhouse effluents are typically evaluated using bulk parameters because of the broad range of wastewater and pollutant loads. Wastewater contains large amounts of biochemical oxygen demand (BOD), chemical oxygen demand (COD), Kjedhal nitrogen (TKN), and total suspended solids [18].

3.4. An Overview of Slaughterhouse Wastewater Characteristics

A study was conducted by Ruiz *et al.* 1997 [19] to assess the feasibility of anaerobic treatment of slaughterhouse wastewaters. The effluent slaughter wastewater has an average COD of 8000 mg/1, of which 70% was proteins. The suspended solids content represented between 15 and 30% of the COD.

As indicated by Masse and Masse, 2000 [20], slaughterhouse wastewater containing 6908 mg/l COD. While, Hamdy Seif and Amal Moursy, 2001 [21] characterize the slaughterhouse wastewater showed the average values of COD, TSS, Orthophosphate of the slaughterhouse wastewater are 4400, 3900, 7.5 m/l, respectively, while pH is 6.8. Caixeta *et al.* 2002 [22] conduct their treatment at slaughterhouse wastewater has the following characteristics; the average BOD ranges from 1300 - 2300 mg/l, while the averages COD ranges from 2000 to 6200 mg/l. Organic and ammonia nitrogen ranges 50 - 210 and 20 - 30 mg/l, respectively. While total phosphate ranges from 15 to 40 mg/l. Total suspended solids range from 850 to 6300 mg/l. The average values of COD, BOD, TSS, TKN-N, of the slaughterhouse wastewater were 6185, 3000, 10120 and 1050 m/l, respectively, while pH is 8 [23]. While the average values of COD, BOD, TSS, oil and grease, phosphate of the slaughterhouse wastewater are 5199, 1680, 7125 m/l, 1266 and 6.8, respectively, while pH is 6.7 as tested by Mijinyawa *et al.* 2008 [24]. Moreover, COD, BOD, and suspended solids in the range of 4700 - 5900 mg/l, 1500 - 2300 mg/l, and 4000 8000 mg/l, respectively as investigated by Sombatsompop *et al.* 2011 [25]. In another experiment by Bazrafshan *et al.*, 2012 [26], the slaughterhouse wastewater characteristics were COD and BOD in the range of 5817 ± 473 and 2543 ± 362 mg/l. Sunder and Satyanarayan, 2013 [27] characterize the slaughterhouse showed COD, BOD and Suspended Solids in the range

of 22,000 - 27,500 mg/l, 10,800 - 14,600 mg/l, and 1280 - 1500 mg/l, respectively. Amin M., 2016 [28] showed the characteristics as COD, BOD, TSS, TKN of the slaughterhouse wastewater are 5817 ± 473, 2543 ± 362 and 3247 ± 845 mg/l, respectively pH 7.31 ± 0.12 and conductivity 9140 ± 1512 μs/cm measured for 48 samples. The mean values of COD, BOD, TSS, TN of the slaughterhouse wastewater are 5000, 3000, 3000 and 450 m/l, respectively and pH is 6.5 [29].

4. Conclusion

The slaughterhouses in Gaza are randomized in place and uncontrolled. The produced wastewater from poultry and private calf slaughterhouses is discharged directly to the public wastewater networks without primary treatment. The only treatment system is for Gaza city slaughterhouse which consists of separation system and aerated lagoon. Due to the lack of energy sources the aerators rarely working and the effluent discharge to the Gaza central wastewater treatment plant causing high organic loading rate. The wastewater production is estimated at around 66 m^3/day with incredible organic load. The average for pH, Electrical conductivity (EC), Dissolved Oxygen (DO), Biological oxygen demand (BOD), Chemical Oxygen demand (COD), Total suspended solids (TSS), Ammonia Nitrogen and Total Kjeldahl nitrogen (TKN) account for 7.1, 3300 μsm, 1.95 mg, 2350 mg/l, 4502 mg/l, 3500 mg/l. 30 mg/l and 154 mg/l, respectively.

An overview of wastewater characteristics showed that, the produced slaughterhouse wastewater in the Gaza Strip is within the range of the reviewed characteristics in all over the world. The wide range of the values among various locations refers to the type of the cleaning system and the used amount of water for cleaning.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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