Meat Processing Industrial Wastewater Treatment

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Translated from the Persian language and reprinted from Issue 6, Water & Sewage.

Increasing population and human activity in diverse agricultural and industrial areas increasingly add enviornmental pollution, the main part of which is borne by water. Therefore, before polluted water is discharged into the environment, the discharge should be treated carefully. This water may contain domestic pollutants, industrial and agricultural wastewater and runoff. Discussion of industrial wastewater is more complicated than domestic wastewater treatment due to its diversity, the different raw materials used by specific industries and the hazards of pollution in the envirnonment. One of the industries operating throughout the world, and the food processing industry in general, is the meat processing industry. This industry includes the slaughter of livestock and poultry, meat packaging and canning. As in other industries, water is consumed in production, which at the final stage will be wastewater containing organic materials and solids. If the discharge of the wastewater is not based on health regulations, severe harm to the human environment can result. Therefore, the discharge of such wastewater should be treated to meet Iranian Evironmental Protection Agency Standards.

Diverse characteristics exist in differing kinds of meat processing wastewater. If the untreated wastewater from meat processing is discharged into streams it can cause the following problems:

I. *The Effect of BOD_5 on Receiving Waters*

Because the wastewater from this industry contains a high amount of organic materials, it has a high BOD_5. When discharged into receiving water, it depletes the amount of Disolved Oxygen (DO) to the zero point. This can cause the destruction of aquatic life and also create noxious odors in the receiving waters (due to the anerobic conditions).

II. *The Effect of Suspended Solids on Receiving Waters*

Usually meat packing wastewater contains high amounts of suspended solids which are both settlable and floatable. If they are discharged into streams they will settle on the stream bed. Some will float to the surface layers obstructing sunlight and the photosyntesis process and causing odor as well as diminishing aesthetics.

III. *The Effect of Grease and Oil on Receiving Waters*

Due to the materials normally used in meat processing, tallow always exists in the wastewater. If this wastewater enters the receiving waters, it causes difficulties such as: coverage of the receiving water surface and resultant prevention of the aeration process and photosynthesis, as well as ecosystem disturbance.

IV. *The Effect of Ammonia on Receiving Waters*

Because the meat packing wastewater of such industries is rich in proteins and chemical structures of proteins, such as amino acids, therefore the presence of ammonia in the wastewater is fully expected. If this wastewater is discharged into receiving waters, then their aquatic life is irrepairably damaged.

Table 1: Wastewater Characteristics According to WHO Research

Parameter	Amount	Unit
Volume of Wastewater	5.33	m^3/ton of LWK
BOD_5	6	kg./ton of LWK
S.S.	5.6	kg./ton of LWK
Grease	2.1	kg./ton of LWK
Kjeldahl	.67	kg./ton of LWK
Chlorate Salts	2.4	kg./ton of LWK
Total Phosphate	0.05	kg./ton of LWK

Table 2: Wastewater Characteristics based on "Guidelines for Industrial Pollution Control" by H.F. Lund

Parameter	Amount	Unit
Amount of Wastewater	500-2,000	Gallons/1,000 lb. LWK
BOD	650-2,200	p.p.m.
Grease	200-1,000	p.p.m.

V. *The Effect of Pathogenic Microorganisms on Receiving Waters*

In this industry, pathogens are usually the carriers of common diseases for animal and man such as Salmonella, Shigella, and Brucella. If they enter into the receiving waters, disease can result.

VI: *The Effect of Wastewater Temperature on Receiving Waters*

The discharge into receiving waters elevates the water temperature and causes the decrease of DO in the surface waters and the death of aquatic life. It also increases the growth of undesirable aquatic plants and fungi. The life cycle of receiving waters can be disturbed.

Water and Wastewater Consulting Engineers have been active from their inception in various wastewater treatment projects, both domestic and industrial. So far they have designed over 100 treatment plants for sewer and wastewater treatment systems, as well as municipal water distribution treatment systems. Some of these plants are already constructed and operational. Twenty-nine of these designs are for industrial wastewater. Among all these designs and plants, the research for three food processing treatment plants were chosen for study in this article. Methods of research and design employed by WWCE include: the study of the production process of raw materials, the amount of raw materials entering the wastewater, sampling of wastewater from various areas in the factories, the completion of necessary tests on wastewater quantity and quality, minimizing the amount of pollution by various methods, finding the best treatment method based on authoritative references and tests carried out by WWCE's lab.

In this article we will discuss the research carried out for Shahrekord Slaughterhouse Wastewater Treatment Plant.

The sites producing wastewater at the Shahrekord plant are as follows:

1. *Pen Area:* Cattle before slaughter may be kept in pens. The wastewater from this section mainly consists of manure and detergent from cleansing the pen floor (afterwards it enters the sewage system). The amount of organic load in the wastewater in this pond is 0.25 kg. BOD_5/ton LWK (Live Weight of Kill).

2. *Cattle & Lamb Slaughter Room:* The wastewater from this section mainly consists of blood from slaughtering with a BOD_5 of 150,000 - 200,000 mg./l. The blood from slaughter is about 5% of the animal weight (mean 23 kg.); 16 kg. of this amount immediately after severing the jugular vein and the remaining 7 kg. in the tannery room lead to the sewer system. The organic load in this section is 3 kg. BOD_5/ton LWK.

In modern slaughter houses, a blood processing unit exists which produces biproducts thus decreasing the organic load of the wastewater. In slaughterhouses with blood processing, usually there are two methods to prepare the blood as a supplement for cattle and poultry food:

a. *Indirect heat use to dry blood:* With this method the amount of organic load of the wastewater is nearly .3 kg.BOD_5/ton LWK.

b. *Direct heat to dry blood:* This method produces an organic load of the wastewater at 1.3 kg. BOD/ton LWK.

In Shahrekord Slaughterhouse, a special conveyer transports the blood from the slaughter of cattle and lamb, after dilution with water, to the slaughterhouse septic tank on the ground floor, along with the wastewater from the other sections. This causes an increase in the organic load of the wastewater, and as such, makes the wastewater treatment imperative.

3. *Hide Separation Room:* In modern systems this is usually a mechanical process. The greatest amount of pollution generated in this room is from the blood resulting from the separation of hide and the external debris from the hide is secondary. The amount of organic load varies considerably. The separated inner layer of the hide is cleaned and salted. The wastewater from this section contains great amounts of dissolved salt and produces an organic load of about 1.5 kg BOD_5/ton LWK. At Shahrekord Slaughterhouse this process is not carried out completely.

4. *Viscera Collection Room:* The resulting wastewater contains 27-40 kg. fertilizer. There are three methods for dumping. The organic load in general dumping processes is 2.5 kg. BOD_5/ton LWK; in wet dumping 1.5 - 2 kg. BOD_5/ton LWK; and in dry dumping .2 kg. BOD_5/ton LWK. In Shahrekord Slaughterhouse the general dumping method is used.

5. *Carcass Cleansing Room:* To prevent the carcasses from decaying, they are washed and maintained at a temperature between 0.5 - 1.5° C. During the final hours of each daily shift, the floors and walls of this room are cleaned. The wastewater from this activity contains blood, viscera parts, and pieces of fat. It is conveyed to the ground floor and the sewer system.

Determining the Quantity & Quality of Shahrekord Slaughterhouse Wastewater:

There are two methods to make this determination:

1. *Field Survey:* This is done according to the maximum number of cattle slaughtered per day (200 head lamb and 25 head cattle).
2. *Use of References:* This is done to compare the amounts of wastewater produced at Shahrekord Slaughterhouse with other slaughterhouses throughout the world.

Regarding table number 3 and the amount of water consumption at Shahrekord Slaughterhouse, the amount of wastewater produced is 5.5 m^3/ton LWK.

Wastewater Quality

WWCE tested the amount of organic load and other parameters from the Shahrekord Slaughterhouse during a four day sampling in complete shifts. The results of these tests are shown in Table 3:

This table shows that for 220 m^3. production of wastewater/day, the amount of BOD_5 in this slaughterhouse is 12.1 kg./ton LWK. Comparison of this figure to tables 1 and 2 shows that the BOD_5 at Shahrekord is very high. The reason is that the entire amount of blood from the livestock is discharged into the sewer. Various experiments have been carried out such as use of chlorine and other chemical coagulants to investigate their effectiveness in decreasing the

Table 3: Test Results from Shahrekord Wastewater by WWCE Lab

Parameters Measured / Date & Location of Tests	pH	Settlable Material after 1 hr.	Unfiltered Residue in 103°-105°	SS in 103°-105° mg/l	Organic Material 550° mg/l	Inorganic Material 550° mg/l	SS mg/l	BOD_5 mg/l	COD mg/l	Total N mg/l	PO_4^{---} mg/l	S^{--} mg/l	Na mg/l	K mg/l
11/21/87 Cattle & Sheep Slaughter rm.		2.55cc / 1000cc		7,080			330	6000	11,140	1,040	7.6	35	100	
11/21/87 Effluent from Skin Separation Room		18cc / 1000cc		1,350			920	1400	3,460	143	9.6	31	90	25
1/20/88 Inlet into Septic Tank (all sewage)		1cc / 1000cc		1,560			240		3,840	270	9	33		20
1/20/88 Effluent from Cattle & Sheep Slaughter rm.	7.55	30cc / 1000cc	5,330	3,720	4,970	360	1610	3600	7,200	3,560	7			
1/20/88 Inlet into Septic Tank (all sewage)	7.8	4cc / 1000cc		652	953	167	468	700	730	92	6			

organic load, the results of which are as follows:

a. *Chlorine alone* up to amounts of 1000 - 15,000 mg/l (up to the organic load of the wastewater). After 12 hours residence time, the color of the wastewater is completely transparent. In this test, the volume of sludge produced between 5 - 20% of wastewater volume, and in most cases there is a small amount of sludge floating on the surface.

b. *Chlorine to 500 mg/l:* It is simultaneously mixed with 500 mg./l ferric chloride ($FeCl_2$). The color of the wastewater is completely removed and the volume of sludge resulting is between 7 to 8% of the volume of the sample.

c. *Aluminum Sulfate & Polyelectrytes:* Amounts of 1000/mg./l aluminum sulfate are mixed simulataneously with 20 mg./ltr. polyelectrolyte. In this case, the color could not be removed effectively.

It can be concluded that if blood and proteins are recovered from the slaughtering process, the amount of organic load in the wastewaer will be decreased. Besides solving the treatment problems, we will have beneficial biproducts.

Case Studies

Among various designs planned by WWCE for treatment of meat processing industrial wastewater, two cases have been chosen which will be discussed: Golshahr and Lavark.

Specific factories should be carefully studied to determine the wastewater type of each individual industry, the production processes and the raw materials. These must be identified from the start. Here is a summary of this information about the raw materials used to manufacture sausage and bologna.

The raw materials in the factories are meat, liquid oil, sodium casenate, starch, flour, soya beans, salt, ice, spices, cellulose and plastic casings.

The main processes of sausage production are:

a. meat grinding
b. adding of various ingredients to the ground meat
c. filling the casings (natural or synthetic)
d. finishing stages including baking, drying and cooling.

The industrial wastewater from these factories includes water from these processes: carcass washing, room cleansing, discharge of warm cooking water from the meat, and washing the machinery.

The volume of industrial wastewater produced in plant no.1 (Golshahr) varies greatly according to the amount of production (5.5 - 7.5 tons/day) and the amount of water consumed. (30 m^3/day). The amount of wastewater ranges between 15 - 30 m^3/day.

In plant no.2 (Lavark), the amount of industrial wastewater before its expansion was constructed was between 40 - 96 m^3/day.

To ascertain the quality of industrial wastewater various foreign sources were consulted. Table 5 shows the information pertaining to the meat packing industry wastewater quality in Russia and Poland.

Table 4: Organic Load of Raw Sewage in Plants Producing Red Meat

Amount of Wastewater (m^3/LWK)	Slaughter (ton/day)	BOD_5 (kg/LWK)	SS (kg/LWK)
Common Slaughterhouses			
# of slaughterhouses	24	24	22
mean	5.328	220	5.6
standard deviation	3.644	135	3.1
range of fluctuation	1.344-14.641	18.5-552	1.5-14.3 .6-12.9
Modern Slaughterhouses			
# of slaughterhouses	19	19	19 16
mean	7.379	595	10.9 9.6
standard deviation	2.718	356	4.5 4.1
range of fluctuation	3.627-12.507	154-1,498	5.4-18.8 2.8-20.5
Meat Packing Small Factories			
# of plants	22	22	20 22
mean	7.842	435	8.1 5.9
standard deviation	4.019	309	6.4 4
range of fluctuation	2.018-17	89-1,394	2.3-18.4 .6-13.9
Meat Packing Large Factories			
# of plants	19	19	19 14
mean	12.514	315	16.1 10.5
standard deviation	4.894	356	6.1 6.3
range of fluctuation	5.444-20.261	8.8-1,222	6.2-30.5 1.7-22.5

Table 5: Wastewater Characteristics in Russian and Polish Slaughterhouses

Parameter	Range of flux in Russia mg./l.	Mean mg./l.	Range of flux in Poland mg./l.
Total Solids at 105°	990-1300	1,145	3,580-12,382
SS at 105°C	600-950	780	686-2,901
Volatile SS	330-524	427	
BOD_5	520-980	750	381-1,879
Total Nitrogen	89-150	115	
Ammonia Nitrogen	52-80	1,200	
Chloride	400-2000	1,200	263-5,684

Wastewater Quantity and Quality at Golshar & Lavark

To determine the quantity and quality of the industrial wastewater, the following measures had to be taken:

Plant No. 1 Golshahr

a. Samples and measurements of the wastewater volume on 7/6/87 are shown in table 6. The curve of the volume fluctuation is in curve 1.

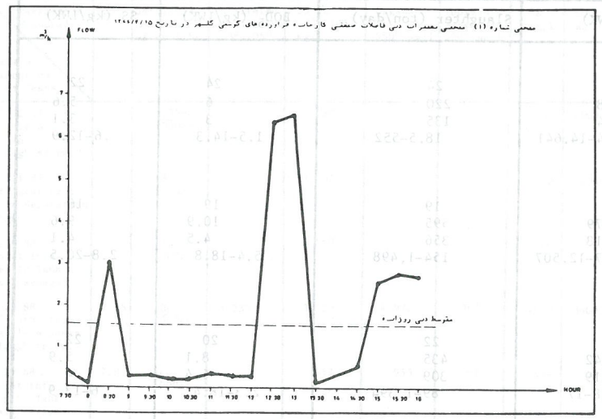
b. The samples from measuring the wastewater volume on 7/20/87. The results are shown in table 6.

c. Samples and measurements from the plants' septic tanks on 8/9/87. The results are shown in table 6.

d. Samples and measurements from the factory septic tanks on 11/21/87.

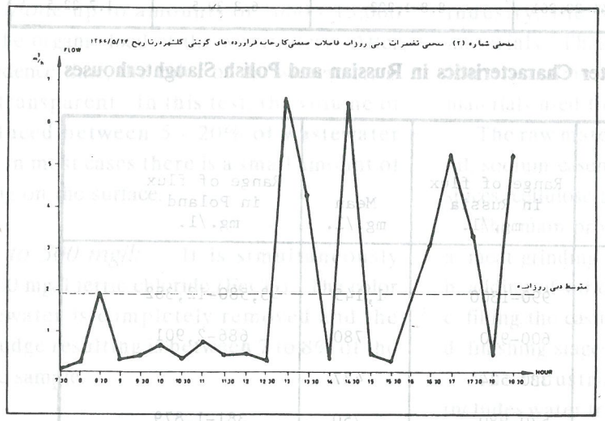
e. Samples and measurements of volumes on 11/23/87. Results are shown in table 6. The volume fluctuation curve is shown in curve 3.

Figure 1: The Fluctuation Curve of Golshahr Sausage and Bologna Plant Wastewater on 7/6/87



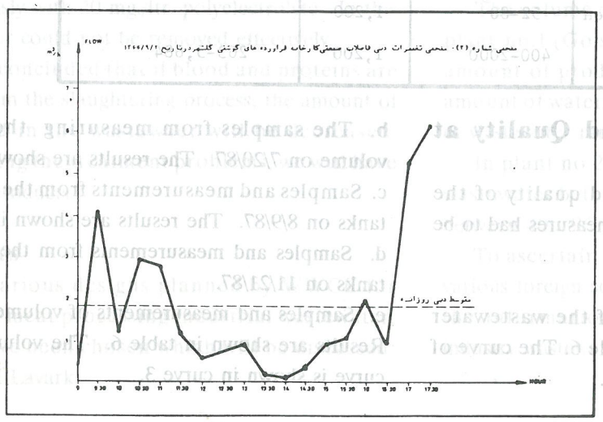
the mean daily curve

Figure 2: The Fluctuation Curve of Golshahr Sausage and Bologna Plant Wastewater on 8/9/87



the mean daily curve

Figure 3: The Fluctuation Curve of Golshahr Sausage and Bologna Plant Wastewater on 11/21/87



the mean daily curve

Table 6: Test Results from Golshahr Meat Packing Plant by WWCE Labs

Parameters Measured / Date & Location of Tests	pH	Settlable Material after 1 hr.	Unfiltered Residue mg/l	Dissolved Solids at 103-105° mg/l	Organic Material at 550° mg/l	Inorganic Material at 550° mg/l	SS mg/l	BOD_5 mg/l	COD mg/l	Total N Kjeldahl mg/l	SO^{--} mg/l	Grease mg/l	Total PO_4^{---} based on P mg/l	Basic T mg/l	Color	Odor & Turbidity
7/6/87 wastewater effluent	5.18	.22 cc/l	4,352	3,907	1,708	2,644	445	1,300	2,450	101	360	450	1.6	380	red	meat & turbid
7/20/87 septic tank	6.48	.1 cc/l	3,080	2,940	878	2,302	140	950	1,550	54			1.6		black	H_2S
8/9/87 wastewater effluent	5.10	.2cc/l	2,888	2,640	716	2,172	248	1,050	1,533	55	362	1	1.4			
11/21/87 septic tank effluent	7.05							910	1,280						gray	wastewater & turbid
11/23/87 wastewater effluent	5.35		4,190	3,880			310	1,420	2,330	50.4	250		6.2		gray	little H_2S & turbid

Table 7: Test Results from Factory No. 2, Lavark

Parameter	Mean	Range of Fluctuation	Mean
pH	6.85	6.1-7.1	
SS after 1 hr., cc/l.	1.10	.4-1.8	
DS, mg./l	1,300.00	966 - 1,665	
Total SS, mg./l.	250.00	379 - 143	
BOD_5, mg./l.	800.00	318 - 1,000	318 - 1,000
COD, mg./l.	1,600.00	1,129 - 1,897	
Grease, mg./l.	407.00	101 - 713	
Color	colorless		colorless
Odor	odorless		odorless
Turbidity	contained SS		

Table 8: The Effect of Lime on Decreasing Organic Load in Factory No. 2, Lavark

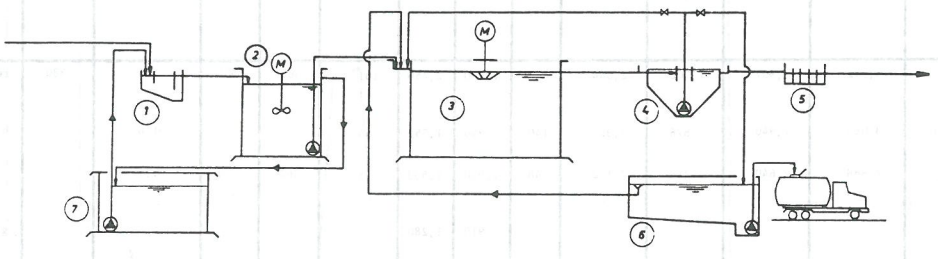
Parameter	Influent Wastewater	Effluent	Efficiency
pH	5.8	6.5	
BOD_5, mg./l.	1,420.0	15.0	98.9
COD, mg./l.	2,230.0	48.2	97.8
SS, mg./l.	450.0	20	95.5

Plant No. 2: Lavark

At this plant the above procedure was used. Table 7 shows the results:

After various tests had been carried out to determine the effect of lime in decreasing the organic load of wastewater in plant no. 2, it was concluded that if lime solution is added as a coagulant, the amount of decrease would be between 37.5 - 45% of wastewater organic load. Considering the low price of lime, its use is economical; and because the formed sludge has no odor, this method is suitable in general.

Based on the measurements and analysis carried out



1-Grease trap chamber
2-Equalisation tank
3-Aeration tank
4-Sedimentation tank
5-Chlorination tank
6-Sludge storage tank]
7-Pre-existant plant septic tank

Flow Diagram: Wastewater Treatment Plant at Golshahr Sausage and Bologna Plant

on industrial wastewater in plant 1, the main design criteria for the industrial wastewater plant will be as follows:

volume of wastewater/ton of product:	4 m^3.
BOD_5:	1,420 mg/l.
COD:	2,230 mg/l.
SS:	450 mg/l.

Based on these results and regarding the different methods to treat wastewater in this industry, the aerobic biological treatment methods have been chosen in the above flow diagram.

Testing Wastewater Treatment Efficiency after Construction and During Operation

Tables 7 and 8 show the physical and chemical characteristics of raw untreated wastewater and treatment effeciences based on the analysis carried out by the Isfahan Environmental Protection Agency.

Conclusion and Recommendations

According to to the above discussion and the present situation of wastewater disposal at these types of plants in our country , the following measures are suggested:

1. Study and design of each meat packing industry treatment plant should be done individually, because according to our conclusion, results from one plant to another cannot be generalized.
2. Meat processing factories must treat their wastewater and to discharge their effluent into receiving water according to environmental standards.
3. The appropriate operational training for this kind of industry should be mandatory in order to reduce the amount of wastewater generated and prevent waste of large amounts of usable materials.
4. In depth analysis should be done in this kind of industry. The causes of their industrial operational deficiencies should be surveyed and recommendations presented to the plants.
5. Factories should be located centrally, when possible, in order to design a common treatment plant/This way operational costs can be reduced.

REFERENCE

BARIVES, D., FORSTER, C.F., and HRUDEY, S.E. Surveys in Industrial Wastewater Treatment: Food and Allied Industries. Pitman Publishing Ltd. London, 1984.