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Investigating the Effect of Livestock and Poultry Slaughterhouses on the Environmental Pollution

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ABSTRACT

Although further development of human societies, industrial advances, and access to new technologies are associated with a large number of advantages and profits, they have caused numerous problems to the human and the environment. One of these problems is the pollution caused by the slaughterhouses. As major centers for production of mean products that generate sewages with high organic loads, livestock slaughterhouses have always been paid attention by environmental specialists. Because slaughterhouses' sewage contains various pathogenic microbes, its unhygienic disposal can pollute water, soil, air, and agricultural products and have harmful effects on the individuals' general health. By developing information and utilizing new technologies, it is hoped that most environmental problems can be controlled in the future and a reasonable balance will be created between technology and environmental protection.

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INTRODUCTION

According to the sustainable development theory, environmental protection is inevitable for the present and the future generations because the crisis of the environmental pollution has nowadays become a global challenge and issue [1, 2]. In this regard, compatibility with the environment is considered as a prerequisite for activities at macro level [3]. Moreover, measuring the emission amount of the environmental pollutants produced by manufacturing and service units is vitally important. Red meat plays an important role in supplying animal protein in human body. The importance of this food product in the household cart and the issue of the environmental pollution caused by meat supplying units necessitate conducting investigations on livestock slaughterhouses as the last loop of animal husbandry chain and the major supplier of red meat to the market. Along with supplying meat products, livestock and poultry slaughterhouses produce other products like skin and bones [2]. The main source of pollutants in the slaughterhouses is a liquid sewage that contains different amounts of solids [4]. The results of the studies conducted on poultry slaughterhouses indicated that the sewage of such units had a density of 3 times more than human sewage [5].

The noteworthy point is that although veterinary authorities supervise the health of meat and slaughtering issues and the environmental specialists supervise the quality of observing the regulations in the slaughterhouses, the issue of the pollution caused by these units is still debating and it is necessary to establish

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supervising organizations in order to control the industrial units. Ignoring the development of such supervising organizations decreases the level of the society's general health and increases environmental pollutions.

Slaughterhouses supply a large amount of meat in order to be directly consumed. Here, a large amount of water containing fat, slaughter blood, and suspended solids forms the slaughter sewage. Because appropriate technology is not used in most slaughterhouses of Iran, initial separation of blood is not done in order to produce side-products (blood powder as protein supplement for livestock rations). Therefore, the blood enters the sewage system and causes the organic load and pollution degree of the sewage to increase, which consequently enhances side costs (environmental consequences and treatment costs).

If the density of the pollutants is not reduced to a standard level, it can endanger the general health of the society by spreading pathogenic agents like plague and cholera and contaminate ground water through sewage absorbing wells (as a method of disposing slaughterhouse sewages). It is obvious that appropriate sewage management practice can reduce the loss of a part of the waste, create value-added (producing side products like blood powder, meat powder, fertilizer, etc.), decrease the level of sewage pollution, and enables the sewage to be reused especially for irrigation purposes [6].

According to the published statistics, most slaughterhouses in Iran are not equipped with the facilities that are required in a hygienic slaughterhouse. Over 90% of the slaughterhouses do not have appropriate systems for treating their sewage. In the conducted study on 426 slaughterhouses without appropriate sewage treatment system, 25.82% of them poured the sewage into rivers, 24.88% used sewage wells dug near rivers, and 25.35% directed it toward the nearby lands. Moreover, 23.94% of the sewage was stored in septic tanks and was carried to seemingly far areas, which causes microbial and environmental contamination in the disposal areas (the project of developing natural resources, 1996; the office of attracting people's participation in livestock supportive association, 2001). Therefore, the inappropriate conditions of slaughtering [7] reduce the quality of the meat and result in failure to reach appropriate profitability from meat production [2].

Jozi and Firouzei [8], in their study, have examined the environmental effects of the Nemuneh poultry slaughterhouse in Tehran. They developed an environmental management program. In this experiment, sampling from the effluent station was conducted during 4 phases (summer 2010, winter 2010-2011, spring 2011, and fall 2011) and related experiments were carried out in order to examine the wastewater quality and the efficiency of the activated sludge system in the slaughterhouse's treatment plant. In this experiment, three parameters of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and pH were measured and analyzed using SPSS. The results of the experiments during these four phases were compared with the standard values. According to the results, only pH parameter was at a standard level (See Table 1).

Table 1: The results of wastewater quality in the treatment plant of Tehran's Nemuneh poultry slaughterhouse and comparing them with standards of sewages disposed in the environment.

Parameter	Unit	spring 2011	fall 2011	summer 2010	winter 2010-2011	Mean	SD	Standard of disposal to the absorbing well
BOD5	mg/l	165	170	150	243	182.00	41.55	50
COD	mg/l	226.9	210	220	437	273.48	109.24	100
pH	_	7.2	7.3	7.1	7.4	7.175	0.096	5-9
TDS	mg/l	11.3	794	1650	2120	-	-	-
Salinity	mg/l	1091	460	983	1790	-	-	-
EC	s/cm	2070	1241	1146	2210	-	-	-
Oil & G	mg/l	-	69	-	-	-	-	10
Coliforms Fecal	N per 100 ml	-	35000	-	-	-	-	400
PO4	mg/l	-	16	-	-	-	-	6
Nitrogen Ammonia	mg/l	-	21	-	-	-	-	_
Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD)								

According to the results of this study, it can be concluded that Tehran's Nemuneh slaughterhouse faces with an inappropriate condition in regard with the environmental and health issues, such that its effects can be observed on the environment of the area especially the social environment, continuation of which can lead to actual consequences in the future. The sewage of Nemuneh slaughterhouse is the most outstanding environmental aspect of this unit. According to the investigations that have been conducted on this slaughterhouse and lack of supervision of the responsible organizations, failure to design a suitable treatment system is the most important issue. It is recommended that further studies should be conducted aiming at evaluating the environmental effects and risks and identifying possible hazards and consequences so that the environment and biological communities can be protected [8].

The effects of livestock waste and sewage on the environment:

Due to scattering of pathogenic bacteria and viruses, pollution of ground and surface water, and gathering of vermin, the sewage produced by livestock and poultry slaughterhouses is a threat to the individuals' health. The sewage resulting from slaughtering animals and washing the carcasses of sheep and cattle contains fat, blood, liquids, and solids inside the animal body, which has a high level of pollution. Slaughterhouse sewage is very similar to domestic wastewater; however, it has a higher density [9]. This type of sewage totally consists of organic materials and a lot of suspended solids and has a high level of BOD.

If these sewages enter surface waters, they will quickly create an unpleasant smell. Therefore, oxygen is required to consolidate such sewages so that they can cause severe contamination in the environment. If the animal blood is separated in the initial stage and dried and prevented from entering the sewage, the characteristics of the sewages will be as follow.

Parameter	Amount (mg/l)
PH	6-7.7
Suspended and floating materials	500-800
BOD	1500-2700
COD	2000-4000

The characteristics of the sewage are different based on its simplicity or complexity. Slaughterhouse sewage is very strong and by having high organic load consisting of blood, protein, and so on can cause critical problems in the area. The sewages produced in these industries run into nearby rivers and farms and pollute them severely and result in surface and ground waters to get contaminated [9, 10].

The most important factors of sewage pollution are BOD, COD, TDS, color, opacity, and microbial pollutants.

Due to being opaque and having a certain color, slaughterhouse sewages create an unpleasant expression. The amount of odor-producing substances is so high that they can have unpleasant effects on human environment. Due to having high levels of BOD and COD, the oxygen level of the river decreases dramatically which causes the death of the aquatic fauna.

The amount of the sewage in the slaughterhouses depends on the method of slaughtering and saving water. A normal volume of 7-9 m^3 water is consumed per one ton of meat. In slaughterhouses, it is estimated that an amount of 10-15 liters sewage is produced per every head of chicken. Due to specific conditions and the complete biological quality of this sewage, different methods of treating can be utilized. Combined aerobic lagoon-biological method has been a practically successful one [9, 11].

Low-cost methods like lagoon systems require vast lands and can only be utilized when the land is cheap and away from the cities. For instance, for slaughterhouses with 100 heads of sheep and 200 heads of cattle, a land of more than 7 acres is required. The implementing cost of lagoon system without including the land cost is normally lower than other methods and there is no need for expert operator.

Common methods like activated sludge and filters have been successfully applied in treatment plants of this type of sewage. These methods need more costs and experts but less land. They also provide high quality treatment. Applying biological mechanical methods in location near cities and populated centers is almost inevitable and combined anaerobic and aerobic methods are very common [11-12].

Anaerobic treatment techniques such as anaerobic biofilters and two-stage digesters have extensively been applied. However, any of these methods is not solely sufficient to treat this type of sewage. Therefore, second-stage treatment is required in order to enhance the quality of the treated sewage up to an acceptable standard.

The amount of slaughterhouses' sewage:

The proportion of slaughterhouse sewage to industrial sewages has differently been reported. For instance, in a report by counseling engineers, 12 liter per every kilogram of meat or 0.3 to 0.4 m^3 per two sheep are reported; however, these figures that are applied by most engineering companies are retrieved from foreign slaughterhouses. It goes without saying that slaughtering system and methods are different in different countries and that the amount of the produced sewage can be affected by the method of slaughtering and whether it is industrialized or not. As a result, these figures cannot be an appropriate pattern of design in Iran [2]. The first amount of the produced sewage in slaughterhouses can be estimated in two methods: by measuring the amount of the consumed water and through the triangular overflow installed along the drainage channel. Fortunately, in recent years, by recycling and cooking the wastes, poultry slaughterhouses produce meat powder as food for poultry, aquatic animals, and livestock.

Livestock bones are also used to make bone powder; however, due to burning bones in this method, it results in air pollution. Bearing in mind the above discussion, it is expected that by developing and applying modern technology, most environmental problems can be controlled and a reasonable balance between technology and environmental protection will be established.

Environmental impact of waste animal product:

The manufacturing of animal products for human consumption (meat and dairy products) or for other human needs (leather), leads inevitably to the production of waste. Under traditional conditions, the quantities of products processed in a certain area used to be small and by-products were better utilized. This resulted in the production of smaller quantities of waste than at present [13, 14].

Nature is able to cope with certain amounts of waste via a variety of natural cleaning mechanisms. However, if the concentration of waste products increases, nature's mechanisms become overburdened and pollution problems start to occur. Usually, small-scale home processing activities produce relatively small amounts of waste and waste water. Nature can cope with these. Yet as a consequence of the increasing emphasis on large scale production (e.g. for reasons of efficiency, increase in scale of production and hygiene) considerably greater amounts of waste will be produced and steps will have to be taken to keep this production at acceptable levels [13].

Also methods will have to be found or developed for a more efficient use of by-products and for improved treatment of waste products. Because large scale processes are not easy to survey, the checking of waste production is a problematic undertaking and special efforts are needed to find out where in the production process waste is produced.

An example that illustrates the relationship between the scale of production and the production of waste is that of the production of hard cheese. Before large scale production of cheese came into existence, whey was considered as a valuable by-product that could be used as animal feed. In the Netherlands, about 50 percent of all the milk produced is used for the production of cheese [14]. The whey which is produced in the process could lead to enormous environmental problems partly because the costs of transport of this whey to the farm for use as animal feed is a costly affair.

Only after environmental considerations had become more important, efforts were made to solve this problem. Eventually this has resulted in the establishment of a production line of whey-powder which is now-a-days considered a valuable product [15].

The example also shows that the borderline between a waste product and a useful product is sometimes hard to draw.

In the present study major attention will be given to the impact on the environment of: (1) the slaughter processes at slaughterhouses; (2) the storage, preservation and processing of hides; and (3) the processing of milk, all at industrial levels. For the discussion concerning the waste production within each of these animal-product-processing industries, it is worth looking at operations that precede and follow the industrial waste producing processes [14, 15].

* In slaughterhouses: the animals are reared, fattened and transported to the slaughterhouses. After processing, the meat is stored before it is transported to retail outlets. The "preceding" activities produce manure etc. while for storage and transport (follow activities) cooling facilities are needed. This puts a heavy claim on energy sources.
* In tanneries: hides produced at slaughterhouses must be stored. To prevent spoilage, they should be pickled and preservatives should be added. The methods used to process hides will to some extent determine the durability of the produced leather. The production of more durable leather leads to smaller quantities of leather waste. Chrome tanned leather and leather products contain about 2-3% of dry weight chromium. Worn out leather products, such as shoes and jackets, are frequently dumped at municipal dumping places.
* Before its collection and transportation to a processing plant, milk is produced and stored at the farm. This requires energy and leads to spoilage of milk and production of wastewater (tank cleaning). After the processing at the plants, dairy products are packed and stored and transported to retailers. At the end of its lifeline, packing material finishes in the form of solid waste. The repeated use of milk bottles produces waste water (after cleansing). At the site of the consumer, storage makes a demand on energy and incorrect storage or usage may lead to spilling. It has been estimated that 2-10% of all dairy products are wasted by the consumer as a result of spoilage.

In general terms, waste products may occur as waste water, solid material, volatile compounds or gasses that are discharged into the air.

Wastewater:

An important environmental impact of the animal processing industry results from the discharge of wastewater. Most processes in slaughterhouses, tanneries and dairy plants require the use of water [16, 17]. This water and water used for general cleaning purposes will produce wastewater. The strength and composition of pollutants in the wastewater evidently depend on the nature of the processes involved. Discharge of wastewater to surface waters affects the water quality in three ways:

1: The discharge of biodegradable organic compounds (BOC's) may cause a strong reduction of the amount of dissolved oxygen, which in turn may lead to reduced levels of activity or even death of aquatic life.
2: Macro-nutrients (N, P) may cause eutrophication of the receiving water bodies. Excessive algae growth and subsequent dying off and mineralisation of these algae, may lead to the death of aquatic life because of oxygen depletion.
3: Agro-industrial effluents may contain compounds that are directly toxic to aquatic life (e.g. tannins and chromium in tannery effluents; un-ionized ammonia).

Biodegradable organic compounds:

Parameters for the amount of BOC's are the Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and the concentration of Suspended Solids (SS). The BOD and COD are overall parameters that give an indication of the concentration of organic compounds in wastewater [18, 19]. The concentration of suspended solids represents the amount of insoluble organic and inorganic particles in the wastewater.

Biochemical Oxygen Demand (BOD):

Agro-industrial wastewater generally contains fat, oil, meat, proteins, carbohydrates, etc., which are generally referred to as bio-degradable organic compounds (BOC). This term is a denominator for all organic substances used and degraded by micro-organisms. For most common organisms present in the aquatic environment, degradation requires oxygen. The BOD is the amount of oxygen required by micro-organisms to oxidize the organic material in the wastewater. The BOD-value is generally measured after a five day incubation period at 20°C. Officially this is expressed as BOD520. In this report the term BOD will be used for the BOD520.

Chemical Oxygen Demand (COD):

The COD represents the oxygen consumption for chemical oxidation of organic material under strongly acid conditions. The COD test yields results within a period of a few hours and therefore provides direct information. In this test biodegradable as well as non-biodegradable compounds are oxidized. The COD therefore only provides an indirect indication of the potential oxygen depletion that may occur from the discharge of organic material in surface waters. Use of the BOD is preferred to that of the COD because it provides a more reliable indication of the degree of pollution of wastewater in terms of bio-degradable matter. Nevertheless, the COD is still a widely used parameter for wastewater in general because of the short period of time within which it can be determined [19, 20]. For slaughterhouse wastewater the COD/BOD ratio varies between 1.5 and 2.2 with an average value of 1.8. [21].

For dairy industries the COD/BOD ratio of the wastewater is 2.63 for low BOD values (< 450 mg/l). For high BOD values (> 450 mg/l) the ratio is 1.25 (EPA, 1971).

Air pollution:

Slaughtering is an activity that requires great amounts of hot water and steam for sterilisation and cleaning purposes. In the process of generating the energy for heating, gasses are emitted (CO2, CO, NOx and SO2).

Emissions of CFC's and NH3 into the air are the result of evaporation of chilling liquids and of the stripping of chilling and freezing-machines, when out of use.

The smoking of meat products and the singing of hogs in a gas flame to complete the hair removal lead to the production of mainly CO2, CO and NOx and obnoxious smells.

The overall energy used in Dutch slaughterhouses and the meat processing industry is estimated at 137 kWh/ton of carcass and about 28.7 m3 gas/ton of carcass [22]. The degree of air pollution caused by the generation of energy depends on the type of process for which the energy is needed. The processes of "dehairing", "water heating" or "production of electricity" each lead to different levels of emission.

Air pollution may cause problems of various kinds:

1: global warming, as a result of emissions of CO2;
2: changes in the ozone-layer, as a result of emissions of NOx, CH4, N2O and CFC's;
3: acid rain, as a result of emissions of SO2 and NH3;
4: health conditions
5: dust (for instance as a result of emission of milkpowder) and/or bad odour, as a result of emissions of VOC;

The use of energy leads to the discharge of gasses such as CO2, CO, NOx and SO2. Chilling and freezing (CFC's and NH3) activities, smoking of meat products and singing/scorching of pigs also lead to emissions into the air.

The discharge of volatile organic compounds (VOC) may occur in dairy plants when cleaning agents are used and in the leather industry when leather finishing substances are used. Dust may be produced in bone cutting and bone processing industries. And the production of milk powder inevitably leads to the production of dust as well.

Singh et al [23], in their study with impact of slaughter house on the environment and health of residents living in its vicinity in India reported that, field investigations have revealed that all the slaughter houses suffer from very low hygienic standards posing both environmental and health hazards due to discrete disposal of waste, highly polluted effluent discharge and burning of bones and hooves etc. Since unauthorized and illicit slaughtering has increased, these problems have also increased manifolds.

Waste generated in the slaughter houses includes both solid (carcass, bones, hooves, rumen, intestine contents, dung etc.) and liquid waste (blood, urine, internal fluids including water used for washing). According to a rough estimate a buffalo weighs about 2 quintals and almost 25 percent of the total body weight becomes waste.

It generates 10 litres of waste blood. Surveys of the slaughter houses have revealed that there were no special waste disposal system or treatment plants. The solid waste is either simply thrown and dumped in the open fields or burnt or sold off to private parties. While the liquid waste is washed away and discharged in nalas

(Chherat drain and Mathura bypass drain) around the slaughtering area. Finally all the water containing blood and debris goes inside the Aligarh drain without treatment. This has led to land degradation, air and water pollution.

Finally these researchers concluded that in India all the slaughter houses on the City Outskirts suffer from very low hygienic standards posing both environment and health hazards due to discrete disposal of waste, highly polluted effluent discharge, burning and boiling of bones, hooves, fat, meat, etc. The results show that for the residents living in the immediate vicinity of the slaughter house, both the environmental conditions and their health conditions were worst.

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