CONCENTRATIONS OF NITRATE, NITRITE, TOTAL KJELDAHL NITROGEN AND POTASSIUM IN EFFLUENTS FROM POULTRY AND SWINE ABATTOIR[1]

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ABSTRACT. Current research aimed to collect information about the risk of wastewaters from swine and poultry abattoirs on the quality of rivers in of São Paulo state, Brazil, in periods of dry and rainy seasons in the region. Water collected sites: supply, different sites in the slaughtering flowchart, affluents and effluents of treatment systems and three sites of the receiving water body (emission locus, 100 m upstream and 100 m downstream) were analyzed. Measurements included nitrate, nitrite, total kjeldahl nitrogen (TKN) and potassium. Results showed that supply waters of the abattoirs complied with Rule 518 of the Health Ministry, (Brazil, 2004) in nitrate, nitrite and TKN. According to CONAMA (2005) and Decree 8486 (São Paulo, 1976), waters of the three sites in the receiving water body in the two types of abattoirs belonged to Classes II and III with regard to nitrate and nitrite concentrations. Such results were not observed on TKN concentrations.

Key words: abattoirs; residual water; macronutrients; nitrate; potassium

CONCENTRAÇÕES DE NITRATO, NITRITO, NITROGÊNIO TOTAL KJELDAHL E POTÁSSIO EM EFLUENTES DE ABATEDOUROS DE AVES E DE SUÍNOS

RESUMO. Este trabalho almejou obter informações dos riscos das águas residuárias, de abatedouros suinícolas e avícolas, na qualidade dos rios no Estado de São Paulo, Brasil, em períodos de maior e menor incidência de chuvas na região. Logo, as águas dos seguintes pontos foram analisadas: abastecimento, diferentes pontos do fluxograma de abate, afluentes e efluentes dos sistemas de tratamento e três pontos do corpo receptor (no seu ponto de emissão, 100 m à montante e 100 m à jusante). As mensurações efetuadas foram: nitrato, nitrito, nitrogênio total kjeldahl (NTK) e potássio. Os resultados reportaram que as águas de abastecimento dos estabelecimentos estavam em acordo com a Portaria 518 do Ministério da Saúde, (Brasil, 2004) em termos de nitrato, nitrito e NTK. As águas dos três pontos do corpo receptor, nos dois tipos de abatedouros, segundo o CONAMA (2005) e o Decreto 8468 (SÃO PAULO, 1976), enquadraram-se nas Classes II e III, em relação às concentrações de nitrato, nitrito; todavia, este fato não foi observado para as concentrações de NTK.

Palavras-chave: abatedouros, água residual, macro-nutrientes, nitrato, potássio

INTRODUCTION

Many researchers, such as Bassoi *et al*. (1990), Benka-Coker e Ojior (1995) and Nieto *et al*. (2000) have been focusing their attention on discharges of wastewater into surface water and the damaging changes which are affecting the ecology of water systems.

Abattoir effluents increase levels of nitrogen, phosphorus, solids and biochemical oxygen demand in receiving water bodies and leave them potentially eutrophized. On the other hand, aerobic microorganisms cause the nitrification of nitrogen and transform it into nitrate and nitrite, its reduced forms (Forman *et al*., 1985; Bruning-Fann *et al*., 1994; Pivelli, 1998; Rodriguez-MArtinez *et al*., 2002).

Nitrate in the water may cause metahemoglobinemia and the formation of cancerigenous nitrosamines and nitrosamides in consumers (Forman *et al*., 1985; Ferreira, 2001). Nitrite in water may trigger metahemoglobinemia, regardless of the age bracket, since its effect is quicker and more acute than that of nitrate (Batalha e Parlatore, 1993). Based on this, the limit rates to ammonium nitrogen for Class II receiving bodies (the most numerous in Brazil) are ≤ 0.5 mg.L^{-1} (Conama, 2005). On the other hand, the limit concentration of ammonium nitrogen for effluents defined by Conama (2005) and by Decree 8468 (São Paulo, 1976) are respectively ≤ 5 mg.L^{-1}.

Food industries have to manage increasing amounts of effluents and simultaneously compare the criteria of environmental conscience with the costs of waste treatment. At the same time, they have to make profits without damaging its image. The consumer, more conscious on environmental problems, will surely choose the ecological concern as one of the main parameters to be taken into account in his/her preference at the supermarket.

Current research aims at defining the levels of the potential pollutant of water and wastewater in poultry and swine abattoirs, during the dry and rainy seasons, in São Paulo state, Brazil. Studies among the points of the slaughterhouses's line and the periods of the year were done.

MATERIALS AND METHODS

A) Characterization of abattoirs

Seven poultry and swine abattoirs in São Paulo state, Brazil, were analyzed. Four poultry abattoirs were under inspection of the State Inspection Service (SISP) and three under the Federal Inspection Service (SIF). With regards to the swine abattoirs, four were under SIF and three under SISP.

B) Characterization of sampling sites, collection and transport of samples

Water sampling sites in poultry abattoirs were supply, scald tank, plucking tank, evisceration, carcass cleaning, pre-cooling tanks, cooling tanks, cleaning of premises, affluent and effluent of the treatment system, emission effluent in the river as well as, 100 m upstream the emission site and 100 m downstream the emission site.

Water sampling sites in swine abattoirs were supply, scald tank, carcass cleaning, cleaning of premises, affluent and effluent of treatment systems, emission effluent in the river and 100 m upstream the emission site and 100 m downstream the emission site.

Collection procedures occurred on working days, in the morning, between the months of May and September 2003 (dry period) and between January and March 2004 (rainy period).

Supply waters from the two types of abattoir, were collected according to American Public Health Association/APHA (1998) and at each sampling site, of the two abattoirs, were placed in two 1000 mL sterilized polyethylene flasks. Determination of 100 m upstream and downstream from the emission of effluents in the river was done by measuring yards.

Samples were transported in isothermal boxes with ice to the Biomass Labs of the Department of Rural Engineering and Lab of Water and Food Analysis of the Department of Preventive Vet Medicine and Animal Reproduction of the Faculty of Agricultural and Vet Science (UNESP) at Jaboticabal, SP, Brazil.

C) Lab analysis

Nitrate (NO_3-N) rates were obtained by cadmium-reducing 8039 method, described in the spectrophotometer handbook DR-2010 (Hach, 1998). Nitrite (NO_2-N) rates were obtained by ferrous sulfate 8507 method, described in the spectrophotometer handbook DR-2010 (Hach, 1998). Results were equivalent to those described by APHA methodology (1998).

Determination of total kjeldahl nitrogen (TKN) was first undertaken by a 23130-18 Digesdahl digestor (Hach, 1999), with a single total digestion of organic matter composed of sulfuric acid and hydrogen peroxide. Second, Nessler method (8075) was used according to spectrophotometer handbook DR-2010 (Hach, 1998) and equivalent to that described by APHA handbook (1998). The readings were done in a spectrophotometer.

Potassium concentrations were measured in extracts from Digesdahl digestor 23130-18 (Hach, 1999). Readings were done in a 932 AA Atomic Absorption Spectrophotometer GBC.

D) Analysis of results

Analysis of results were done by Tukey's Test at 5% level of significance with the PROC UNIVARIATE of the Statistical Analysis System, version 8,02 (SAS, 1996) and descriptions by Steel e Torrie (1960). For these statistical analysis it was used the proceeds PROC GLM.

RESULTS AND DISCUSSION

Tables 1 and 2 show mean concentrations of total kjeldahl nitrogen (TKN), nitrate, nitrite and potassium in the supply water, slaughtering flowchart site, affluents and effluents of treatment systems and at the sites of the receiving water bodies, respectively in poultry and swine abattoirs, during the dry and rainy seasons.

Johns (1995), Fransen *et al*. (1998), Rajeshwari *et al*. (2000), Salminen *et al*. (2001), Salminen e Rintala (2002) and Manios *et al*. (2003) agree that approximately 90% of total nitrogen in the waters is in the form of ammonium nitrogen.

According to Law 518 of the Health Ministry (Brasil, 2004) and to RIISPOA (Brasil, 1997), which respectively determined maximum rates of 1.5 $mg.L^{-1}$ and 5.0 $mg.L^{-1}$ of ammonium nitrogen for water used for human consumption and for industries of animal products, it may be said that values in supply waters of the two types of abattoir (Tables 1 and 2) under analysis are within the procedures regulated by RIISPOA (Brasil, 1997) only.

When supply water of the two types of abattoir is dealt with, nitrate and nitrite concentrations, during the dry and rainy periods, matched with maximum values 10 $mg.L^{-1}$ and 1 $mg.L^{-1}$, respectively, in compliance with Law 518 of the Health Ministry (Brasil, 2004).

Concentrations of TKN (supply site and three sites of the receiving water body), potassium (supply, scalding, plucking, 100 m upstream and 100 m downstream from effluent emissions), nitrite (scalding, plucking, affluent and effluent of treatment systems and 100 m upstream) and nitrate (effluent of treatment systems, 100 m upstream and 100 m downstream) in water from poultry abattoirs during the rainy and dry seasons showed significant differences ($p<0.05$) when compared to other sampling sites (Table 1).

Statistic differences ($p<0.05$) occurred in TKN concentrations (supply and the three sites of the receiving water body), nitrite (slaughtering flow, affluent and effluents of treatment system), nitrate (affluents and effluents of treatment system) and potassium (100 m upstream and 100 m downstream) in swine abattoirs during the dry and rainy seasons with other sampling sites (Table 2).

It has also been reported, especially on statistical information, that wastewaters of the entire slaughtering line of both types of abattoirs have high polluting factors when TKN and nitrate concentrations in wastewater samples of the two types of abattoir are taken into account. On the other hand, with regard to nitrite and potassium rates in poultry abattoirs during the dry and rainy seasons, the highest pollutant rates in wastewater were found in the scalding and plucking tanks, followed by water from evisceration, cleaning of carcass, pre-cooling and cooling tanks, and cleaning of premises.

In the swine slaughtering line, water from carcass and premise cleaning, followed by water from scald

Table 1. Arithmetic means average TKN, nitrate (NO_3-N), nitrite (NO_2-N) and potassium (K) values, in mg.L^{-1}, in supply water and of different phases of the slaughtering flowchart, in affluents and effluents, of waste treatment systems, and in three sites of the receiving water body in poultry abattoirs, **between May and September 2003 (dry period) and between January and March 2004 (rainy period), in São Paulo State, Brazil**

SAMPLING SITES	TKN		NO_3-N		NO_2-N		K	
	DRY	RAINY	DRY	RAINY	DRY	RAINY	DRY	RAINY
Supply	2.9 Ab (2.47-3.35)*	4.4 Ab (4.2-4.6)	1.1Aa (1.1-1.2)	0.8 Aa (0.7-0.8)	0.007 Aa (0.006-0.0074)	0.004 Aa (0.038-0.042)	0 Aa (0)	4.5 Ba (4.3-4.8)
Scald tank	270.0 Aa (256.5-283.5)	250.7 Aa (238.2-263.3)	14.2 Ab (13.5-15.0)	22.3 Ab (21.2-23.4)	0.808 Ab (0.767-0.848)	2.318 Ab (2.202-2.434)	194.8 Ab (185.1-204.5)	186.0 Ab (176.7-195.3)
Plucking tank	369.8 Aa (351.3-388.3)	302.1 Aa (287.0-317.2)	8.8 Ab (8.4-9.2)	16.9 Ab (16.1-17.8)	1.465 Ab (1.391-1.538)	1.734 Ab (1.648-1.821)	114.1 Ab (108.4-119.8)	109.2 Ab (103.7-114.6)
Evisceration	290.0 Aa (275.5-304.5)	260.7 Aa (247.7-273.7)	12.1 Ab (11.5-12.7)	24.1 Ab (22.9-25.3)	0.249 Ac (0.236-0.262)	0.417 Ac (0.396-0.438)	48.5 Ac (46.1-50.9)	40.1 Ac (38.1-42.1)
Carcass cleaning	317.7 Aa (301.8-333.6)	387.1 Aa (367.7-406.5)	13.1 Ab (12.5-13.8)	14.5 Ab (13.8-15.2)	0.125 Ac (0.119-0.131)	0.243 Ac (0.231-0.255)	16.3 Ac (15.5-17.12)	27.8 Ac (26.4-29.2)
Pre-cooling	286.1 Aa (271.8-300.4)	270.7 Aa (257.2-284.2)	9.7 Ab (9.2-10.2)	9.7 Ab (9.2-10.2)	0.086 Ac (0.082-0.090)	0.139 Ac (0.132-0.146)	32.4 Ac (30.8-34.0)	69.2 Ac (65.7-72.7)
Cooling	195.3 Aa (185.5-205.0)	121.8 Aa (115.7-127.9)	6.2 Ab (5.9-6.5)	8.8 Ab (8.4-9.2)	0.082 Ac (0.078-0.086)	0.065 Ac (0.062-0.068)	18.0 Ac (17.1-18.9)	36.1 Ac (34.3-37.9)
Cleaning of premises	295.8 Aa (281.0-310.6)	205.0 Aa (194.8-215.3)	10.4 Ab (9.9-11.0)	23.2 Ab (22.0-24.4)	0.131 Ac (0.125-0.138)	0.309 Ac (0.294-0.325)	59.5 Ac (56.5-62.5)	58.2 Ac (55.3-61.1)
Affluent of treatments	288.2 Aa (273.8-302.6)	124.6 Aa (118.4-130.9)	13.1 Ab (12.5-13.8)	21.2 Ab (20.1-22.3)	2.295 Ab (2.180-2.410)	0.951 Ac (0.904-0.999)	23.3 Ac (22.1-24.5)	45.7 Ac (43.4-47.9)
Effluent of treatments	264.6 Aa (251.4-277.8)	143.2 Aa (136.0-150.4)	4.8 Ac (4.6-5.0)	3.1 Ac (2.9-3.3)	0.160 Ac (0.152-0.168)	0.413 Ac (0.392-0.434)	24.3 Ac (23.1-25.5)	64.6 Ac (61.4-67.9)
Emission site in the river	16.13 Ac (15.3-16.9)	13.69 Ac (13.0-14.4)	2.4 Ac (2.3-2.5)	2.1 Ac (2.0-2.2)	0.031 Ac (0.030-0.033)	0.076 Ac (0.072-0.080)	22.8 Ac (21.6-24.0)	33.2 Ac (31.5-34.9)
100 m downstream from emission	28.55 Ac (27.1-30.0)	19.50 Ac (18.5-20.5)	1.7 Ac (1.6-1.8)	1.2 Aa (1.1-1.3)	0.052 Ac (0.049-0.055)	0.021 Ac (0.020-0.022)	0 Aa (0)	9.0 Bd (8.6-9.5)
100 m upstream from emission	19.08 Ac (18.1-20.0)	16.22 Ac (15.4-17.0)	2.2 Ac (2.1-2.3)	0.9 Aa (0.9-1.0)	1.056 Ab (1.003-1.109)	0.052 Bc (0.049-0.055)	6.5 Ad (6.2-6.8)	6.2 Ad (5.9-6.5)

Values followed by different capital letters, in each line, within a variable, differ among themselves, by Tukey´s test at 5% of probability.
In each column, values followed by different small letters, within a variable, differ among themselves, by Tukey's test at 5% of probability.
* = The values, in the parenthesis, are the minimum and maximum values, respectively.

Table 2. Arithmetic averages of TKN concentrations, nitrate (NO_3-N), nitrite (NO_2-N) and potassium (K) values, in mg.L^{-1}, in supply waters and in different phases of the slaughtering flowchart, in affluents and effluents of the waste treatment systems and, in three sites of the receiving water body, collected in swine abattoirs between May and September 2003 (dry season) and between January and March 2004 (rainy season) in São Paulo State, Brazil

SAMPLING SITES	TKN		NO_3-N		NO_2-N		K	
	DRY	RAINY	DRY	RAINY	DRY	RAINY	DRY	RAINY
Supply	4.6Ab (4.4-4.9)*	3.1 Ab (3.0-3.3)	1.5 Aa (1.4-1.6)	1.7 Aa (1.6-1.8)	0.001 Aa (0.0009-0.0011)	0.006 Aa (0.0057-0.0063)	2.0 Aa (1.9-2.1)	3.6 Aa (3.4-3.8)
Scald tank	303.8 Aa (288.6-319.0)	305.7 Aa (290.4-321.0)	30.0 Ab (28.5-31.5)	34.0 Ab (32.3-35.7)	0.461 Ab (0.438-0.484)	0.424 Ab (0.403-0.445)	21.1 Ab (20.0-22.2)	19.8 Ab (18.8-20.8)
Carcass cleaning	360.5 Aa (342.5-378.5)	397.1 Aa (377.2-417.0)	32.8 Ab (31.2-34.4)	38.0 Ab (36.1-39.9)	1.323 Ac (1.257-1.389)	1.223 Ac (1.162-1.284)	52.6 Ab (50.0-55.2)	52.5 Ab (50.0-55.1)
Cleaning of premises	467.7 Aa (444.3-491.1)	374.6 Aa (355.9-393.3)	32.0 Ab (30.4-33.6)	28.6 Ab (27.2-30.)	1.485 Ac (1.411-1.560)	1.284 Ac (1.220-1.349)	25.5 Ab (24.2-26.8)	21.0 Ab (20.0-22.1)
Affluent of treatments	264.3 Aa (251.1-277.5)	92.1 Bb (87.5-96.7)	37.6 Ab (35.7-39.5)	28.5 Ab (27.1-29.9)	0.653 Ac (0.620-0.686)	0.620 Ac (0.589-0.651)	25.7 Ab (24.4-27.0)	23.9 Ab (22.7-25.1)
Effluent of treatments	304.8 Aa (289.6-320.0)	91.3 Bb (86.7-95.9)	3.62 Aa (3.4-3.8)	2.2 Aa (2.1-2.3)	0.102 Ab (0.097-0.107)	0.111 Ab (0.106-0.117)	38.7 Ab (36.8-40.6)	36.9 Ab (35.0-38.8)
Emission site on the river	24.75 Ac (23.5-26.0)	60.0 Ab (57.0-63.0)	2.8 Aa (2.6-2.9)	2.7 Aa (2.6-2.8)	0.117 Ab (0.111-0.123)	0.176 Ab (0.167-0.185)	21.3 Ab (20.2-22.4)	26.5 Ab (25.2-27.8)
100 m downstream emission	29.25 Ac (27.8-30.7)	22.5 Ac (21.4-23.6)	2.1 Aa (2.0-2.2)	2.3 Aa (2.2-2.4)	0.245 Ab (0.233-0.257)	0.174 Ab (0.165-0.183)	7.6 Aa (7.2-8.0)	8.0 Aa (7.6-8.4)
100 m upstream emission	31.88 Ac (30.3-33.5)	15.0 Ac (14.3-15.8)	2.8 Aa (2.6-2.9)	1.0 Aa (0.9-1.1)	0.147 Ab (0.140-0.154)	0.107 Ab (0.102-0.112)	6.1 Aa (5.8-6.4)	6.2 Aa (5.9-6.5)

Values followed by different capital letters, in each line, within a variable, differ among themselves, by Tukey's test at 5% of probability.
In each column, values followed by different small letters, within a variable, differ among themselves, by Tukey's test at 5% of probability.
* = The values, in the parenthesis, are the minimum and maximum values, respectively.

tank, mostly contributed, in nitrite terms, towards water pollution. In the case of potassium, the three stages in the slaughtering line were non-differentiating ($p>0.05$) pollutant agents.

TKN, nitrate and potassium results in affluents and effluents of the treatment systems of poultry and swine abattoirs under analysis were similar to those reported by COUILLARD *et al.* (1989), BENKA-COKER e OJIOR (1995), JOHNS (1995), KELLER *et al.* (1997), DEL POZO *et al.* (2000), RAJESHWARI *et al.* (2000), MASSE e MASSE (2001), SALMNEN *et al.* (2001), CAIXETA *et al.* (2002), RODRIGUES-MARTINEZ *et al.* (2002), SALMINEN e RINTALA (2002), DEL POZO e DIEZ (2003) and TORKIAN *et al.* (2003).

Abattoir wastes are generally defined as a difficult substrate for anaerobic treatment due to their typically high rates of proteins and lipids (RAJESHWARI *et al.*, 2000; FRANSEN *et al.*, 1998; SALMINEN *et al*, 2001; SALMINEN e RINTALA, 2002; MANIOS *et al*, 2003). Stabilization ponds in most countries are the main types of aerobic biological treatments for abattoir affluents although other technologies such as biological filters and activated sludge systems exist (JOHNS, 1995).

High level anaerobic treatment systems, such as UASB and fixed-bed reactors, are less common for abattoir wastes, due to the high levels of oil and suspended matter in the affluent, jeopardizing its performance and efficiency (RAJESHWARI *et al.*, 2000; FRANSEN *et al.*, 1996; SALMINEN e RINTALA, 2002; MANIOS *et al.*, 2003). However, RODRIGUEZ-MARTINEZ *et al.* (2002) state that anaerobic systems are highly used in the treatment of abattoir wastewaters since they provide high BOD reductions at a low cost, when compared to aerobic systems. Further, they produce a lesser quantity of highly stabilized sludge which may easily be dehydrated. Moreover, methane-rich gas produced may be employed as an energy source.

Although several physical, chemical and biological technologies have been developed to remove nutrients, the removal of nitrogen by nitrification biological processes has been enhanced (SALMINEN e RINTALA, 2002).

Denitrification of oxidized nitrogen and methanogenic degradation occur simultaneously in anaerobic processes, although both processes are limited by the availability of biodegradable matter. Organic matter in nitrification is chiefly the immediate biodegradable fraction, especially for abattoir wastewater, since most COD should be previously hydrolyzed. Consequently, COD concentrations, limited by denitrification, may reach high rates, as up to 500 $mg.L^{-1}$ (DEL POZO e DIEZ, 2003).

Treatment systems for poultry abattoir effluents had the following decreasing rates: 8.2% (dry season) for total nitrogen; 63.4% (dry season) and 85.4% (rainy season) for nitrate and 93.0% (dry season) and 56.6% (rainy season) for nitrite.

In swine abattoirs, decrease amounted to 0.9% (rainy period) for total nitrogen; 90.4% (dry period) and 92.3% (rainy period) for nitrate and 84.4% (dry period) and 82.9% (rainy period) for nitrite.

High concentrations of TKN and low reduction rates of this element in the treatment systems of the two types of abattoir agree with research by SALMINEN *et al.* (2001) and CAIXETA *et al.* (2002). These authors state that in the aerobic degradation of organic matter, the removal of organic nitrogen occurs coupled to an increase in ammonium nitrogen concentrations and to the maintenance of alkalinity. This fact causes moderate acidity which reduces significant nitrogen losses caused by the volatilization of ammonia during treatment.

There are no laws in Brazil on maximum nitrogen rates in the effluent at the emission site. However, the European Community rules that over 80% removal rates should be reached or 15 $mg.L^{-1}$ concentrations (FATTA *et al.*, 2003). Poultry and swine abattoir effluents failed to reach maximum limits of TKN.

TKN at the three sites of the receiving water body of the effluents of the wastewater treatment systems in the two types of abattoir was extremely higher than maximum concentrations of 0.5 $mg. L^{-1}$, according to Decree 8468 (SÃO PAULO, 1976) for Class II and III waters, and 1 $mg. L^{-1}$ ruled by CONAMA (2005) for Class III water body.

Nitrate and nitrite concentrations in receiving water bodies (site of effluent emission; 100 m upstream; 100 m downstream) which received effluents of the treatment systems of poultry and swine abattoirs, during the dry and rainy periods, complied with Resolution 357 of CONAMA (2005) and to Decree 8468 (São Paulo, 1976), or rather, they were below maximum values of 10 mg NO_3-N. L^{-1} and 1 mg NO_2-N. L^{-1} for Class II and III waters.

Low nitrate concentrations in the samples downstream the emission site during the rainy season show the river's dilution and self-cleansing ability. TNK irregular concentrations (above maximum values) in waters 100 m upstream from the emission site of the effluents of the two types of abattoir may be related to other pollution sources, specific or not, and regardless of the abattoirs. It should be emphasized that high concentrations of potassium, reported in current research, corroborate results by Frank *et al.* (1991), Bruning-Fann *et al.* (1994) and Barros (2002). Through logistic models, these researchers revealed a positive association between nitrate values, over 10 mg.L^{-1}, and an increase in potassium levels.

Since potassium (together with nitrogen) is also required as a nutrient in most biological processes, its contribution towards eutrophization and flowering of aquatic environments is very high. Several species which produce fatal toxins to living beings, including humans, may be found.

CONCLUSIONS

The wastewaters of the entire slaughtering line, of both types of abattoirs, have high polluting factors when TKN, nitrate and nitrite concentrations are taken into account. In the case of potassium, the three stages in the swine slaughtering line didn't show contribution to the polluting; but, in the poultry slaughtering line, there was a contribution for the environmental impact.

TNK irregular concentrations in the receiving water body 100 m upstream from the effluent emission site of the two types of abattoir showed other sources of pollution, which may be specific or not, and regardless of the abattoirs' effluents.

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REFERENCES

AMERICAN PUBLIC HEALTH ASSOCIATION (APHA). **Standard methods for the examination of water and wastewater.** 20.ed. Washington: 1998.

BARROS, L. S. S. **Avaliação do potencial de contaminação microbiológica e química de águas residuárias de suinocultura, após a utilização de um sistema integrado de tanques de estocagem e deposição em diferentes tipos de solos.** 2002. 132 f. Dissertação (Master's Thesis in Veterinary Medicine) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal, 2002.

BASSOI, L.J.R. NIETO ; TREMAROLI ,D. **Implementação de testes de toxicidade no controle de efluentes líquidos.** São Paulo: Cetesb/Procop,1990. p.irreg. (Série Manuais/Secretaria do Meio Ambiente).

BATALHA, B. H. L. ; PARLATORE, A. C. **Controle da qualidade da água para consumo humano:** bases conceituais e operacionais. São Paulo: Cetesb, 1993. p. irreg. (Série Manuais/Secretaria do Meio Ambiente).

BENKA-COKER, M. O. ; OJIOR, O. O. Effect of slaughterhouse wastes on the water quality of Ikpoba river, Nigeria. **Bioresource Technology,** v.52, p. 5-12, 1995.

BRASIL. Decreto nº 2.224 de 05 de julho de 1997. Aprova o novo Regulamento da Inspeção Industrial e Sanitária de Produtos de Origem Animal. Diário Oficial [da] União. Poder Executivo, Brasília-DF, 1997.

BRASIL. Leis e Decretos. Portaria nº 518 de 25 de março de 2004. Norma de qualidade da água para consumo humano. Disponível em: http://www.anvisa.gov.br/legis/portarias/1469_00.htm>. Accessed on May 5, 2005.

BRUNING - FANN, C.,J. B. et al. The use of epidemiological concepts and techniques to discern factors associated with the nitrate concentration of well water on swine farms in the USA. **Science of the Total Environment,** Amsterdam, v.153, p. 85-96, 1994.

CAIXETA, C. E. T. et al. Slaughterhouse wastewater treatment: evaluation of a new three-phase separation system in a UASB reactor. **Bioresource Technology**, v..81, p. 61-69, 2002.

CONSELHO NACIONAL DO MEIO AMBIENTE. Padrões de Qualidade para os Parâmetros Monitorados na Rede de Monitoramento, segundo Resolução Conama357/05. Disponível em: <http://

www.cetesb.sp.gov.br/qualidadederios/anexo2>. Accessed on May 5, 2005.

COUILLARD, D. S. et al. Slaughterhouse effluent treatment by thermophilic aerobic process. **Water Research,** Oxford, v.23, p.573-579, 1989.

DEL POZO, R. et al. Anaerobic pre-treatment of slaughterhouse wastewater using fixed-film reactors. **Bioresource Technology,** v.71, p.143-149, 2000.

DEL POZO, R. ; DIEZ, V. Organic matter removal in combined anaerobic-aerobic fixed-film bioreactors. **Water Research,** Oxford, v. 37, p. 3561-3568, 2003.

FATTA, D., M. et al. Development of guidelines on best practices for the slaughter of animals in Cyprus. **Waste Management,** v. 23, p.157-165, 2003.

FERREIRA, F. L. **Eficiência de um sistema integrado de biodigestão na redução da carga poluidora de águas residuárias de suinocultura.** 2001. 69 f. Dissertação (Master's Thesis in Vet Medicine) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal, 2001.

FORMAN, D. et al. Nitrates, nitrites and gastric cancer in Great Britain. **Nature,** London, v.313, p.620-625, 1985.

FRANK, R. et al. Survey of farm wells for nutrients and minerals. **Bulletin of Environmental Contamination,** Heidelberg, v. 47, p.146-151, 1991.

FRANSEN, N. G. et al. Pathogenic micro-organisms in slaughterhouse sludge-a survey. **International Journal of Food Microbiology**, v. 33, p. 245-256, 1996.

FRANSEN, N. G. et al. Fermentation of aerobically activated pig slaughterhouse sludge for animal feed purposes. **Bioresource Technology,** v. 65, p.145-150, 1998.

HACH COMPANY WORLD HEADQUARTERS. **Procedures Manual of DR-2010 Spectrophotometer Handbook.** Loveland: 1998.

HACH COMPANY WORLD HEADQUARTERS. **Instruction Manual of Digesdahl Digestion Apparatus**. Loveland: 1999.

JOHNS, M. R. Developments in wastewater treatment in the meat processing industry: a review. **Bioresource Technology**, v. 54, p.203-2161, 1995.

KELLER, J., K. et al. Nutrient removal from industrial wastewater using single tank sequencing bath reactors. **Water Science and Technology,** p. 35, p: 137-144, 1997.

MANIOS, T. E. et al. Closed wastewater cycle in a meat producing and processing industry. **Resources, Conservation and Recycling**, v. 38, p.335-345, 2003.

MASSÉ, D. I.; MASSE, L. The effect of temperature on slaughterhouse wastewater treatment in anaerobic sequencing batch reactors. **Bioresource Technology**, v.76, p.91-98, 2001.

NIETO, R. Caracterização ecotoxicológica de efluentes líquidos industriais – ferramenta para ações de controle da poluição das águas. In: Congresso Interamericano de Engenharia Sanitária e Ambiental, Porto Alegre. **Anais eletrônicos...** Porto Alegre: Abes, 2000. Available at: < http://www.abes-dn.org.br.htm >. Accessed on 13 Dec. 2000.

PIVELLI, R. P. **Qualidade das águas**. São Paulo: Faculdade de Saúde Pública da USP, 1998.

RAJESHWARI, K. V. et al. State-of-the-art of anaerobic digestion technology for industrial wastewater treatment. **Renewable and Sustainable Energy Reviews**, v.4, p.135-156, 2000.

RODRÍGUEZ-MARTÍNEZ, J. et al. Kinetics of anaerobic treatment of slaughterhouse wastewater in batch and upflow anaerobic sludge blanket reactor. **Bioresource Technology**, v.85, p.235-241, 2002.

SALMINEN, E., J. et al. Anaerobically digested poultry slaughterhouse wastes as fertiliser in agriculture. **Bioresource Technology**, v.78, p. 81-88, 2001.

SALMINEN, E. A.; RINTALA, J. A. Semi-continuous anaerobic digestion of solid poultry slaughterhouse waste: effect of hydraulic retention time and loading. **Water Research**, v. 36, p.3175-3182, 2002.

SÃO PAULO. Decreto nº 8.468, de 31 de maio de 1976. Aprova o regulamento da Lei nº 997, de 31 de maio de 1976, que dispõe sobre a prevenção e o Controle da Poluição do Meio Ambiente. Diário Oficial [do] Estado. Poder Executivo, São Paulo, SP, 1976.

SAS INSTITUTE SAS/STAT. **Procedures guide for personal computers.** Version 6.12. Cary: 1996.

STELL, R. et al. **Principles and procedures of statistics**. New York: Mc Graw-Hill, 1960.

TORKIAN, A. et al. The effect of organic loading rate on the performance of UASB reactor treating slaughterhouse effluent. **Resources, Conservation and Recycling,** v. 40, p.1-11, 2003.