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PRELIMINARY REPORT

PROJECT NO. B-134

WATER QUALITY PROBLEMS

Prepared for

GEORGIA STATE BOARD OF HEALTH

Water Quality Division

By

Robert S. Ingols and

Peter E. Gaffney

August 25, 1958

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

ENGINEERING EXPERIMENT STATION
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August 25, 1958

Preliminary Report, Project No. B-134

I. INTRODUCTION

Due to expansion of the poultry industry in the city of Gainesville, Georgia, the municipal sewage treatment plant cannot adequately treat all the waste entering the sewage system. In addition to the necessity of bypassing some of the wastes directly to Lake Lanier, the plant itself is operating at peak capacity and thus is ineffective in treating that portion of the sewage which it accepts.

The specific purposes of the project are:

(1) To determine the polluting characteristics of liquid wastes discharged from the poultry houses in the area.

(2) To use these data in calculation of the pollutional load contributed through the processing in terms of pounds of 5-day BOD per chicken. With these data available, it will be possible to estimate the overall pollution load (in terms of population equivalents) contributed to the city sewerage system by the poultry industry. Such data could further be used as a basis for design criteria for future isolated treatment installations.

(3) To determine the efficiency of the present treatment facilities and the effect of poultry wastes on treatment.

II. METHODS AND PROCEDURE

(1) Samples of waste were obtained from six poultry houses on different days and at hourly or half-hourly intervals during specific days.

(2) At the treatment plant, samples of raw sewage, filter influent, and filter effluent were obtained.

The data in Table I show that in certain plants (A and D), the BOD may vary over a very wide range during a given day. On the day of sampling, Plant D was processing a large number of hens. The hens contributed a large amount of fat to the waste samples. One sample had a BOD of greater than 10,000 ppm. This fat is responsible for the high BOD load per bird.

The two primary sources of liquid wastes from these plants are the flow that carries entrails to the screens and that which carries blood and feathers. Analyses were performed on these separate wastes at one Plant (B) and the BOD results are presented in Table II. These data show that the water carrying entrails has a very high BOD but is still only half of that containing the blood and feathers.

TABLE II

HOURLY* VARIATIONS IN SEPARATE WASTES AT PLANT B

		Entrails	Blood & Feathers
5-day BOD (ppm)	Min.	187	237
	Max.	1401	2868
	Avg.	450	780

* 10:30 AM - 10:30 PM; 13 samples each

In Table III is presented a summary of BOD, COD, and SS data from the poultry houses. Ranges of daily samples and averages are given along with an overall average for four plants. On these plants (A-D) water data were available so the pollutional value of a chicken could be calculated. Plants E and F use water from the city and also from a well. The amount taken from the latter could not be ascertained, thus making impossible

TABLE IV

DATA ON PLANTS E AND F

Plant	Avg. head /day	COD (ppm)			5-day BOD (ppm)			Susp. Sol. (ppm)		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
E	32,450	126	1351	756	260	1456	618	44	508	264
F	40,792	563	4201	2205	366	2423	1534	340	1316	831

Since only two of the four plants listed in Table III have Government inspectors on the premises, the high range of water consumption (5-10.7 gal. per bird) was unexpected.

The average number of birds processed per day is approximately 40,000. Since the overall average BOD load per bird is 0.04 lb, the population equivalent represented by a 40,000 bird/day plant is approximately:

$$\frac{0.04}{0.17} \times 40{,}000 = 10{,}000 \text{ capita/day.}$$

B. Treatment Plant

The raw data on the treatment plant samples are given in Appendix II. An attempt was made to select the salient features from these data and these results are given in Tables V and VI.

In Table V are presented the ranges and average BOD, COD, and

An estimation of the efficiency of treatment can be obtained by considering the data in Table VI where the percentage removals of BOD and suspended solids are shown.

TABLE VI

TREATMENT PLANT EFFICIENCY

Date	SS	Per cent Removal of BOD		
	Primary Tank Eff.	Primary Tank	Filter (once)	Filter (twice)
5-1	81	39	--	47
5-6	--	--	35	33
5-9	--	--	0	0
5-13	--	--	0	0
5-16	46	8	32	39
5-20	--	--	50	55
5-23	--	--	9	--
5-30	35	3	12	13
6-3	50	35	80	--
6-10	9	0	--	34
6-13	25	18-32	55-74	--
6-17	45	--	--	--
Summary				
May	35-81	3-39	0-50	0-55
June	9-50	18-35	55-80	34

The data in this table show that there are large variations in plant efficiency from day to day. We feel that part of this variation may have been due to a temperature effect and for this reason have grouped the results for May and June separately (at bottom of table). However, differences in influent BOD (from 200-600 ppm) cannot be overlooked as an additional and probably an important factor affecting efficiency.

The plant was designed to treat an influent containing 500 ppm BOD in a volume of 2.5 mgd. At the time these samples were obtained the average BOD was 425 but the approximate flow thru the plant was 4.0 mgd. If these values are extended over one day, the plant would be handling an excess of approximately 4000 lb of BOD daily:

IV. DISCUSSION

Since this is not a final report it may be pointed out that the BOD loading value of 0.04 lb per chicken as presented here must be limited at the present time due to our observations of a "sliding scale" in the BOD data on the pountry wastes. As seen in Appendix I, in the majority of cases the BOD increased with increasing dilution of the waste samples. This is indicative of toxicity or nitrification - with toxicity being the most likely explanation since chlorine water is used in washing operations and in at least one plant, it is known that a crude antibiotic is used during a process called "achronizing". If toxicity is playing a role in our BOD analyses, it is possible that the actual BOD load per chicken is higher than that presented.

Bolton (1) reports an average of 0.028 lb BOD per head and an average water consumption of 6.0 gallons per head on waste flows of poultry houses in Alabama.

At a plant in Dobson, N. C., it has been reported (2) that water consumption was 7.6 gallons per bird and the waste contained a BOD load of 0.026 lb per bird.

Water consumption in Gainesville's industries is comparable but the BOD load as presented here is 0.01 lb per head higher. Even considering

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(1) Bolton, J. M., "Wastes from Pountry Processing Plants", 13th Annual Purdue Industrial Waste Conference, 1958.

(2) A report by the Pollution Control Section of the N. C. State Board of Health, Raleigh, N. C., 1957.

bird. The range is 5.0 - 10.7 gal/bird with the highest consumption in a Government inspected plant.

2. In terms of BOD load, each bird processed yields 0.04 lb of 5-day BOD. Thus, a 40,000 bird per day plant represents a population equivalent of 10,000 capita per day.

3. In terms of suspended solids loading, each bird processed yields 0.023 lb of solids. A 40,000 bird per day plant would therefore represent a population equivalent of 5600 capita per day.

4. During poultry processing hours, the treatment plant was operating at peak capacity. Average BOD removal during May and June was 42 per cent. The high-rate filters designed for 1.0 - 1.5 lb of BOD per cu yd are loaded at 3.0 lb per cu yd. Due to an average flow of 4.0 mgd and frequent peaks up to 5.4 mgd, detention time in the primary sedimentation tanks is half the design figure and average suspended solids removal is 42 per cent. It is most likely that the digestors are underloaded with respect to normal solids and due to the relatively high grease concentration, sludge (of 15 per cent solids) floats at the top of the digestion tank.

VI. FUTURE WORK

1. Determine the nature of the oxidation curve with these poultry wastes and if toxic substances exert an effect on BOD.

2. The BOD load contributed through chicken processing as presented in this report will be supplemented with additional data on wastes from

VII. APPENDICES

Appendix A

Raw Data on Poultry Wastes

TABLE VII (Continued)

Plant B

Date	pH	C.O.D.	B.O.D. RAW WASTE Sample Vol. (cc) 0.5	1.0	1.5	B.O.D. SETTLED WASTE Sample Vol. (cc) 0.5	1.0	1.5	Suspended Solids	Total Nitrogen
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
5/1/58	6.25	3309	1537	1350					1240	130
5/6/58	6.50	3153	750	532	525				520	96
5/13/58	6.45	636	370	347	311	136	166	121	270	19
5/20/58	7.00	1720	1018	967		419	530	451	644	112
(entrails) 5/27/58	6.90	450	190	185		156	125	114	140	16
(bloody feathers) 5/27/58	6.90	1258	1228	928		464	447	462	496	103
(entrails) 6/2/58	6.15	800	534	441		481	412		268	10
(blood) 6/2/58	6.40	1776	678	894		370	372	359	672	102
(entrails) 6/10/58	6.55	565	189	338	304	170	362	317	204	23
(blood) 6/10/58	6.50	1169	491	468	591	733	188	317	4440	28

TABLE VII (Continued)

Plant E

Date	pH	C.O.D.	B.O.D. RAW WASTE Sample Vol. (cc) 0.5	1.0	1.5	B.O.D. SETTLED WASTE Sample Vol. (cc) 0.5	1.0	1.5	Suspended Solids	Total Nitrogen
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
5/1/58	6.60	1000	1456						204	80
5/6/58	6.70	600	331	336	329				164	
5/9/58	7.00	126	356	353					210	51
5/13/58	6.45	1020	239	276	266	78	193	200	44	58
(wash only) 5/20/58	6.95	141	152	131	147	142	139	132	48	
5/20/58	6.65	353	630	514		631	339	348	340	51
5/27/58	7.00	1132	686	705		511	449	429	508	57
6/2/58	6.80	1082	810	466	473	263	265	286	256	33
6/10/58	7.00	1351	756	621	697	241	523	648	384	52

TABLE VIII

Hourly Variations

Plant A

Time	COD ppm	BOD ppm
11:00 AM	1767	1370
12:00	1914	1703
1:00 PM	1790	1884
2:00	1584	814
3:00	1511	792
4:00	1863	1075
5:00	745	572
6:00	1346	767
7:00	215	293
8:00	41	210
9:00	124	239
10:00	0	196

Plant B

	Entrails		Blood & Feathers	
Time	COD ppm	BOD ppm	COD ppm	BOD ppm
10:30 AM	562	306	1090	599
11:30	606	362	1230	819
12:30 PM	158	187	435	560
1:30	616	472	1730	1481
2:30	624	500	1160	694
3:30	674	520	1152	466
4:30	633	648	1020	597
5:30	550	373	902	720
6:30	607	416	865	567
7:00	2200	1401	2300	2868
8:30	175	215	405	296
9:30	374	348	460	237
10:30	92	209	313	526

VII. APPENDICES (Continued)

Appendix B

Raw Data on Gainesville Treatment Plant

TABLE IX (Continued)

Sample	Ali-quots	THURS.(Fri.) 5/16/58 B.O.D. raw	B.O.D. set	COD	Solids	TUES.(Mon.) 5/20/58 B.O.D. raw	B.O.D. set	COD	Solids	FRI.(Thurs.) 5/23/58 B.O.D. raw	B.O.D. set	COD	Solids	FRI.(Thurs.) 5/30/58 B.O.D. raw	B.O.D. set	COD	Solids
(A) Plant Influent	1 ml	474	276	840	280					190	176	405	256	566	474	628	186
	2 ml	335	329							252	125			417	306		
	4 ml	408	301							276	177			355	245		
(B) Primary #1	1 ml	402	248	528	152	668	446	228	180					518	532	562	120
	2 ml	371	271			549	358							411	391		
	4 ml	343	269			323	384							373	309		
(C) Filter #1(once)	1 ml	236	211	360	142	281	198	383	100	251	197	384	70	530	395	678	286
	2 ml	308	237			259	206			237	176			359	225		
	4 ml	281	234			234	173			166	170			293	184		
(D) Filter #1(twice)	1 ml	250	110	400	192	203	106	377	200					508	391	595	220
	2 ml	223	167			250	163							354	251		
	4 ml	270	169			246	152							301	179		

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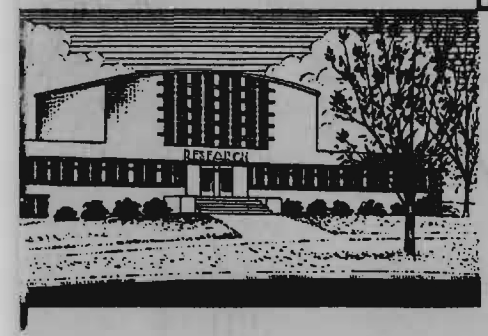

Engineering Experiment Station
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I. INTRODUCTION

Because of the expansion of the poultry industry in North Georgia, it was considered desirable to study the effect of poultry-processing wastes upon sewage treatment. The city of Gainesville was chosen for this study because there are eight poultry plants discharging wastes to the sewerage system.

The specific purposes of the project were:

(1) To determine the polluting characteristics of liquid wastes discharged from the poultry-processing plants in the area.

(2) To use these data in calculation of the pollutional load contributed through the processing in terms of pounds of 5-day BOD per chicken. With these data available, it is possible to estimate the overall pollution load (in terms of population equivalents) contributed to the city sewerage system by the poultry industry. Such data could further be used as a basis for design criteria for future treatment installations.

(3) To determine the efficiency of the present treatment facilities at Gainesville and the effect of poultry wastes on treatment.

II. METHODS AND PROCEDURE

In general, the sampling techniques used at each of the plants were those of spot samples. That is to say, the samples were taken between 2 PM and 4 PM in the afternoon when the plants were in full operation. Those few samples that were taken when the plant was not in operation are noted in the report. One-quart ball fruit jars were used as sampling containers. Samples of poultry plant wastes were placed in a large wooden box to which ice was added. The samples, having been taken to the labora-

tory, were placed in a refrigerator overnight; the analyses were performed early the next day.

Where possible, samples were taken in the plant from the water which had been used to wash the freshly killed chickens (which contained the feathers) and from the water that washed the cut-up chickens (which contained the entrails). Otherwise the combined wastes were sampled as they entered the sewer.

At Plant A, the spot samples were taken from the overflow pipe of the general or mixed waste weir box, at the wastes-solids-collecting shed near the plant. The pipe, approximately 6 inches in diameter, took the mixed wastes from two rotating screens. The bottle was filled to the brim and immediately capped. The samples that were obtained on the day of the full run of this plant were taken from a new recirculation pit located outside of the newly completed plant expansion. Some of the water from the pit was recirculated back through the defeathering machines but the samples represent a composite of the flow going to the screening shed and thus to the sewer.

At Plant B, combined samples were taken from the recycling reservoir. This reservoir was located below the two separate rotary screens.

At Plant C, samples were taken from the reservoir tank after the material had passed through a 20-20 vibrating screen filter.

Plant D uses one vibrating screen for all wastes. The samples were taken by dipping the ball jar down into the reservoir tank as in the other plants. It is believed that this technique was adequate for the spot sampling.

At Plant F, it was possible to obtain separate wastes samples, (one containing the feathers and the other containing the entrails). Samples were taken from the tanks beneath the screens where the waste enters the recirculation reservoir.

In the clean-up cycle of the chicken plants it was noted that grit from the slicing of the gizzards was washed down the troughs and finally washed into the reservoir basin at the end of the day. At the close of these operations the tanks were cleaned with a fire hose so that the grit was forced into the sewer line. Thus, no effort was made to recover or to remove any of this grit for separate disposal.

The samples at the sewage treatment plant were taken in quart jars and were returned to the laboratory immediately and placed in the refrigerator along with the samples taken from the chicken plants for that trip. In determining the efficiency of the filters, 30 minutes delay was allowed for the filter to readjust itself to the new flow conditions. Dip samples of the raw sewage were taken past the grit chambers. The samples of the primary settled sewage were taken from the overflow of the weir around these tanks. Samples from the trickling filter with recirculation were taken from the circular rotating arm of that filter because the direct discharge of the filter was recycled. Samples were taken from the center of the secondary clarifier to represent the discharge of the filter.

All samples were analyzed at Georgia Tech for BOD, COD, and suspended solids according to the techniques of Standard Methods. In addition, the poultry waste samples were analyzed for pH, total nitrogen, and detergents.

Water consumption data for the poultry houses were obtained from municipal records at City Hall in Gainesville. Processing data (number of

birds processed on specific days) were obtained from plant records.

III. RESULTS

A. Poultry Wastes

Samples of waste from three of the plants were taken at hourly or half hourly intervals to determine the changes in the characteristics of the wastes during processing. The BOD results are summarized in Table I. The results in this table show the range of BOD concentration which may be expected during the sampling period. The supporting data are presented in Appendix A (Table IX).

TABLE I

HOURLY VARIATIONS IN BOD

Plant	Time	Number of Samples	5-Day BOD			BOD Load/Bird		
			Min. (PPM)	Max. (PPM)	Avg. (PPM)	Min. (Lb)	Max. (Lb)	Avg. (Lb)
A	11AM-6PM	8	572	1884	1122	0.204	0.079	0.047
C	10AM-2:30PM	9	352	627	446	0.021	0.036	0.027
D	10AM-1PM	6	676	3197	1671	0.039	0.182	0.095

The data in Table I show that in certain plants (A and D), the BOD may vary over a very wide range during a given day. On the day of sampling, Plant D processed fryers during the morning and hens during the last 2 hours of operation. The hens contributed much more fat to the waste samples than did the fryers. Three waste samples during hen processing had BOD values which were greater than 4200 ppm. But these values were

omitted from calculation of the average (Table I) because the exact BOD was not obtained.

The two primary sources of liquid wastes from these plants are (1) the flow that carries entrails to the screens, and (2) the flow which carries blood and feathers. Analyses were performed on these separate wastes at Plant B and the BOD results are presented in Table IX (Appendix) and summarized in Table II. These data show that the water carrying entrails has a BOD of 450 ppm, but this BOD is still only about half that of the water containing the blood and feathers (780 ppm).

TABLE II

HOURLY* VARIATIONS IN SEPARATE WASTES AT PLANT B

	5-Day BOD (PPM)	
	Entrails	Blood & Feathers
Min.	187	237
Max.	1401	2868
Avg.	450	780

* 10:30 AM-10:30PM; 13 samples each

Table III presents a summary of BOD, COD, and suspended solids data from the poultry-processing plants. Ranges of daily samples and averages are given along with an overall average for four plants. On these plants (A-D) water data were available, enabling the calculation of the pollutional value of a chicken. Plants E and F use water from the city and also from a well. The amount taken from the latter could not be ascertained,

thus making impossible any calculations of BOD per chicken. The data (taken from Appendix A, Table VIII) for these two plants are summarized in Table IV.

TABLE III

OVERALL BOD AND COD DATA ON PLANTS A, B, C, AND D

Plant	Avg. Gal/ Head	Avg. Head/ Day	COD Min. (PPM)	COD Max. (PPM)	COD Avg. (PPM)	Lb COD /Head Avg.	5-Day BOD Min. (PPM)	5-Day BOD Max. (PPM)	5-Day BOD Avg. (PPM)
A	10.7	29,246	316	879	665	.059	158	563	386
B	5.4	35,350	636	3309	2205	.099	343	1444	846
C	6.2	42,602	759	1121	940	.049	408	674	519
D	5.0	51,900	1032	3104	1502	.062	511	2163	1294
Overall Average	6.8	39,775	686	2103	1328	.067	355	1211	761

Plant	BOD/Head Min. (Lb)	BOD/Head Max. (Lb)	BOD/Head Avg. (Lb)	Avg. Lb/ Head	Lb BOD /Lb Chicken	Susp. Solids Min. (PPM)	Susp. Solids Max. (PPM)	Susp. Solids Avg. (PPM)	Lb SS* /Head (Avg.)
A	.026	.043	.035	3.0	.012	80	234	323	.020
B	.018	.067	.041	3.1	.013	270	1240	669	.030
C	.020	.033	.025	3.2	.008	264	300	281	.015
D	.018	.100	.055	---	---	120	1512	592	.025
Overall Average	.021	.061	.039	3.1	.011	184	847	444	.023

* Suspended Solids

TABLE IV

DATA ON PLANTS E AND F

Plant	Avg. Head /Day	COD			5-Day BOD			Susp. Solids		
		Min. (PPM)	Max. (PPM)	Avg. (PPM)	Min. (PPM)	Max. (PPM)	Avg. (PPM)	Min. (PPM)	Max. (PPM)	Avg. (PPM)
E	32,450	126	1351	756	260	1456	618	44	508	264
F	40,792	563	4201	2205	366	2423	1534	340	1316	831

The average number of birds processed per day is approximately 40,000 per plant. Since the overall average BOD load per bird is 0.04 lb, the population equivalent represented by a 40,000 bird/day plant is approximately

$$\frac{0.04}{0.17} \times 40{,}000 = 10{,}000 \text{ capita/day/plant.}$$

The above values (in Tables II and IV) are based on BOD of the wastes as they enter the sewers (unsettled). BOD determinations were also made on supernatants of these wastes after settling for one hour in the laboratory. The BOD values obtained on these wastes after sedimentation are presented in Table V.

TABLE V

BOD OF POULTRY-PROCESSING WASTES AFTER SEDIMENTATION

Plant	5-Day BOD		
	Min. (PPM)	Max. (PPM)	Avg. (PPM)
A	66	324	230
B	141	467	304
C	315	602	478
D	283	1568	713
E	138	471	323
F	124	1330	727
			Overall avg. = 463

The results in Table V show that proper sedimentation of these wastes would result in a 40-per-cent BOD reduction. On this basis, the average load would be reduced to 0.24 lb of BOD per bird.

B. Treatment Plant

The supporting data on the treatment plant samples are given in Appendix B. An attempt was made to select the salient features from these data and the summarized results are given in Tables VI and VII.

TABLE VI

SUMMARY OF RESULTS ON TREATMENT PLANT SAMPLES

			5-Day BOD		Suspended Solids
		COD (PPM)	Unsettled (PPM)	Settled (PPM)	(PPM)
Influent	Min.	405	239		186
	Max.	1020	646		498
	Avg.	766	425		303
Primary No. 1 (filter influent)	Min.	134	125	170	96
	Max.	794	513	411	276
	Avg.	522	369	291	176
Filter No. 1 (through once)	Min.	287	123	68	72
	Max	678	394	268	346
	Avg.	449	244	170	247
Filter No. 1 (through twice)	Min.	169	182	96	92
	Max.	849	388	274	402
	Avg.	499	265	186	228

Table V presents the ranges and averages (BOD, COD, and suspended solids) on samples obtained on 12 different days at various points within the treatment plant. The primary tank and filter effluent samples were also allowed to settle in the laboratory for one hour and BOD values are given on the settled supernatants.

These data show that the average influent BOD was 425 ppm and that of the primary tank effluent was 369 ppm. Thus, 13 per cent of the raw waste BOD was removed during primary sedimentation. Laboratory settling tests revealed that, performed under proper conditions, primary sedimentation could reduce the BOD of the effluent from 369 to 291 ppm, a reduction of 31.5 per cent. After settling the filter effluent (through once) in the laboratory, the BOD was 170 ppm. This is a 54-per-cent reduction in the BOD load that was applied to the filter. Apparently, the BOD or COD of the waste was not further reduced by recirculation of this filter effluent (as shown in Table VII).

TABLE VII

TREATMENT PLANT EFFICIENCY

Date	Suspended Solids	BOD Removal By		
	Primary Tank Eff.	Primary Tank (%)	Filter (Once) (%)	Filter (Twice) (%)
5/1	81	39	--	47
5/6	--	--	35	33
5/9	--	--	0	0
5/13	--	--	0	0
5/16	46	8	32	39
5/20	--	--	50	55
5/23	--	--	9	--
5/30	35	3	12	13
6/3	50	35	80	--
6/10	9	0	--	34
6/13	25	18-32	55-74	--
6/17	45	--	--	--
Summary				
May (Min.-Max.)	35-81	3-39	0-50	0-55
June (Min.-Max.)	9-50	18-35	55-80	34

An estimation of the efficiency of treatment can be obtained by considering the data in Table VI where the percentage removals of BOD and suspended solids are shown.

The data in this table show that there are large variations in plant efficiency from day to day. Part of this variation may have been due to a higher average temperature in June and for this reason the results for May and June have been grouped separately (at the bottom of the table). However, variations in influent BOD (from 200 to 600 ppm) must be considered as an additional and important factor affecting efficiency.

The plant was designed to treat an influent containing an average of 500 ppm BOD in a volume of 2.5 mgd. At the time these samples were obtained the average BOD was 425. This BOD value was within the acceptable limit, but the volume of the continuous daytime (approximately 10 hours) flow through the plant was 4.0 mgd, exceeding the acceptable limit by 1.5 mgd.

Based on the original design, the plant should be able to handle short peak loads of approximately 850 lb BOD per hour. Under existing conditions, there is a sustained (or continuous) daytime peak load of 1100 lb BOD per hour due to poultry processing. (This load of 1100 lb BOD per hour is based on the average influent BOD and not on the maximum.)

In addition to the BOD loading problems, sludge is floating in the digestion tanks. This is most likely due to the unusually high grease and feather content of the sludge from the combined waste.

Sedimentation efficiency is much lower than would be expected with plain domestic sewage.

The BOD data in Table VII (Appendix A) show a "sliding scale," i.e., the BOD increases upon dilution of the poultry waste samples. The BOD values presented in the preceding tables are averages of the values obtained with different sample volumes in which the sliding scale was manifest.

IV. DISCUSSION

The sliding scale observed in the BOD determinations on the poultry plant wastes could be due to either of two phenomena: toxicity or nitrification.

With regard to toxicity, chlorine water is used during a process called "achronizing." If the sliding scale obtained was caused by toxicity of these components, the BOD load per chicken would actually be higher than that presented (0.04 lb) because the toxic agents would be diluted upon mixture with the domestic sewage in Gainesville.

On the other hand, if the sliding scale was caused by nitrification in the BOD bottles, the true BOD load would be lower than the value presented.

The value of 0.04 lb of BOD per chicken, as determined in this study, is significantly higher than that obtained by others, although the volumes of water used per chicken are comparable. Bolton[1] reports an average BOD of 0.028 lb per head in waste flows from poultry plants in Alabama. It has also been reported[2] that at a plant in Dobson, North Carolina, water consumption was 7.6 gallons per head and the waste contained a BOD load of 0.026 lb per bird. The BOD load value of 0.024 lb per head with the settled wastes in Gainesville would be comparable. The differences between the values previously reported by other workers and the values for the Gainesville unsettled wastes may be explained to a certain extent by the fact that on certain days

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[1] J. M. Bolton, "Wastes from Poultry Processing Plants," 13th Annual Purdue Industrial Waste Conference, 1958.

[2] A report by the Pollutional Control Section of the North Carolina State Board of Health, Raleigh, North Carolina, 1957.

Plant D was processing hens during the sampling period. These hens contributed a large amount of fat to the waste. Plant D was also the plant that had the lowest water consumption (5.0 gallons per head).

In order to resolve the discrepancy between experimental results and those given in the literature, further work should be performed to determine whether toxicity or nitrification affected the BOD results obtained. Based on the data obtained to date, however, the BOD load of 0.04 lb per chicken means that the operation of eight poultry-processing plants in Gainesville would represent a population equivalent of approximately 80,000 capita per day in terms of BOD, the average number of birds processed per plant per day being 40,000.

During poultry-processing hours, the BOD load of the waste entering the Gainesville sewage treatment plant exceeded continuously the maximum hourly design load of the plant. Primary sedimentation removed 13 per cent of the BOD instead of the 30- to 40-per-cent optimum in the design specifications. The average filter efficiency, even with recirculation, was 54-per-cent removal of the applied BOD load. The large amount of fat in the waste results in an excess of scum which accumulates in the digester. Here, the high grease content and the light-weight feathers cause a low density sludge that floats as a scum layer on the digesting mass.

V. SUMMARY AND CONCLUSIONS

Analyses have been made on waste samples from six poultry-processing plants in the City of Gainesville and on samples collected at various points within the municipal sewage treatment plant. On the basis of the results obtained thus far, the following conclusions are derived:

(1) At the plants studied, the average number of birds processed per day ranges from 29,000 to 52,000; the overall average being 40,000. Water consumption ranges from 5.0 to 10.7 gal/bird with the highest in a Government-inspected plant.

(2) In terms of BOD load, each bird processed yields 0.04 lb of 5-day BOD. Thus, a 40,000-bird-per-day plant represents a population equivalent of 10,000 capita per day.

(3) Sedimentation of the poultry-processing wastes would result in a 40-per-cent reduction in BOD load.

(4) In terms of suspended solids loading, each bird processed yields 0.023 lb of solids. A 40,000-bird-per-day plant would therefore represent a population equivalent of 5600 capita per day.

(5) During poultry-processing hours, the treatment plant was operating with a continuous BOD load significantly higher than the maximum hourly design load. The average reduction of BOD applied to the filters was 54 per cent even with recirculation. Because of an average flow of 4.0 mgd and frequent peaks up to 5.4 mgd, detention time in the primary sedimentation tanks was half the design figure and average suspended solids removal was 42 per cent; BOD removal was 13 per cent. It is most likely that the digesters are loaded with a very high percentage of low density solids because of the relatively high grease concentration and large number of feathers; the sludge of 15 per cent solids floats at the top of the digestion tank.

VI. FUTURE WORK

(1) Determine the nature of the oxidation curve with these poultry wastes to evaluate whether toxic substances exert an effect on BOD.

(2) Supplement the data on the BOD load contributed through chicken processing as presented in this report with additional data on wastes from several other poultry houses.

(3) Supplement the data on treatment plant samples with more comprehensive results on hourly composites.

(4) Determine the effect of temperature on the efficiency of the filters.

(5) Find a method of preventing an accumulation of sludge in the top portion of the digesters.

Respectfully submitted:

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Project Director

Approved:

Wyatt C. Whitley, Chief
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VII. APPENDICES

Appendix A

Detailed Data on Poultry Wastes

TABLE VIII

DETAILED DATA ON POULTRY-PROCESSING WASTES

Plant A

Date	pH	COD (PPM)	BOD Raw Waste Sample 0.5 (PPM)	BOD Raw Waste Vol. 1.0 (PPM)	BOD Raw Waste (CC) 1.5 (PPM)	BOD Settled Waste* Sample 0.5 (PPM)	BOD Settled Waste* Vol. 1.0 (PPM)	BOD Settled Waste* (CC) 1.5 (PPM)	Suspended Solids (PPM)	Total Nitrogen (PPM)
5/1/58	6.40	852	611	515					334	64
5/6/58	6.75	793	550	358	370				292	58
5/9/58	6.80	333	308	391	304				142	26
5/13/58	6.35	603	417	270	295	191	158	248	186	22
5/20/58	6.90	316	206	126	143	66	76	55	80	26
(wash only) 5/23/58	8.20	28	73	39	22				9	
5/27/58	6.85	721	559	442		391	358	223	252	93
6/2/58	6.50	825	404	392	394	287	264	276	276	28
6/10/58	6.50	879	427	322	400	318	234	297	296	45

* The data in those columns of BOD values marked Settled are those results obtained upon the sample after one hour of settling in the laboratory.

(Continued)

TABLE VIII (Continued)

DETAILED DATA ON POULTRY-PROCESSING WASTES

Plant B

Date	pH	COD (PPM)	BOD Raw Waste Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	BOD Settled Waste* Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	Suspended Solids (PPM)	Total Nitrogen (PPM)
5/1/58	6.25	3309	1537	1350					1240	130
5/6/58	6.50	3153	750	532	525				520	96
5/13/58	6.45	636	370	347	311	136	166	121	270	19
5/20/58	7.00	1720	1018	967		419	530	451	644	112
(Entrails) 5/27/58	6.90	450	190	185		156	125	114	140	16
(Bloody feathers) 5/27/58	6.90	1258	1228	928		464	447	462	496	103
(Entrails 6/2/58	6.15	800	534	441		481	412		268	10
(Blood) 6/2/58	6.40	1776	678	894		370	372	359	672	102
(Entrails) 6/10/58	6.55	565	189	338	304	170	362	317	204	23
(Blood) 6/10/58	6.50	1169	491	468	591	733	188	317	4440	28

* The data in those columns of BOD values marked Settled are those results obtained upon the sample after one hour of settling in the laboratory.

(Continued)

TABLE VIII (Continued)

DETAILED DATA ON POULTRY-PROCESSING WASTES

Date	pH	COD (PPM)	BOD Raw Waste Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	BOD Settled Waste* Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	Suspended Solids (PPM)	Nitrogen (PPM)
Plant C										
5/27/58	6.80	759	509	442		387	328	231	280	10
6/2/58	6.40	939	421	427	376	486	599	468	264	40
6/10/58	6.20	1121	658	634	729	515	641	651	300	13
Plant D										
5/13/58 (heavy fat)	6.10	1032	2163			532	571	526	1512	
5/20/58	6.80	3104	2075			1529	1607		756	121
5/27/58	6.65	1132	1251	918		534	734	445	120	103
6/2/58	6.55	1143	648	587	298	275	338	236	320	54
6/10/58	6.45	1097	845	509	559	983	351	459	252	3

* The data in those columns of BOD values marked Settled are those results obtained upon the sample after one hour of settling in the laboratory.

(Continued)

TABLE VIII (Continued)

DETAILED DATA ON POULTRY-PROCESSING WASTES

Plant E

Date	pH	COD (PPM)	BOD Raw Waste Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	BOD Settled Waste* Sample Vol. (CC) 0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	Suspended Solids (PPM)	Total Nitrogen (PPM)
5/1/58	6.60	1000	1456						204	80
5/6/58	6.70	600	331	336	329				164	
5/9/58	7.00	126	356	353					210	51
5/13/58 (wash only)	6.45	1020	239	276	266	78	193	200	44	58
5/20/58	6.95	141	152	131	147	142	139	132	48	
5/20/58	6.65	353	630	514		631	339	348	340	51
5/27/58	7.00	1132	686	705		511	449	429	508	57
6/2/58	6.80	1082	810	466	473	263	265	286	256	33
6/10/58	7.00	1351	756	621	697	241	523	648	384	52

* The data in those columns of BOD values marked Settled are those results obtained upon the sample after one hour of settling in the laboratory.

(Continued)

TABLE VIII (Concluded)

DETAILED DATA ON POULTRY-PROCESSING WASTES

Plant F											
			BOD								
			Raw Waste			Settled Wastes*					
			Sample Vol. (CC)			Sample Vol. (CC)			Suspended	Total
Date	pH	COD (PPM)	0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	0.5 (PPM)	1.0 (PPM)	1.5 (PPM)	Solids (PPM)	Nitrogen (PPM)
5/6/58	7.65	4201	3192	2322	1754				1316	492
5/13/58	6.75	563	262	469		55	219	98	340	22
5/20/58	7.60	2908	1813			1184	1476		836	381
(blood) 5/27/58	7.25	3260	1884			1863			968	372
(entrails) 6/2/58	6.85	653	371	286	298	166	249	176	324	8
(blood) 6/2/58	7.25	3633	1698			2230	1430		1100	318
(entrails) 6/10/58	6.80	681	276	370	257	215	235	247	268	3
(blood) 6/10/58	7.00	1744	1775			979	1285		1240	367

* The data in those columns of BOD values marked Settled are those results obtained upon the sample after one hour of settling in the laboratory.

TABLE IX

HOURLY VARIATIONS IN BOD AND COD--RAW DATA

Plant A

Time	COD (PPM)	BOD (PPM)
11:00 AM	1767	1370
12:00	1914	1703
1:00 PM	1790	1884
2:00	1584	814
3:00	1511	792
4:00	1863	1075
5:00	745	572
6:00	1346	767
7:00	215	293
8:00	41	210
9:00	124	239
10:00	0	196

Plant B

Time	Entrails		Blood & Feathers	
	COD (PPM)	BOD (PPM)	COD (PPM)	BOD (PPM)
10:30 AM	562	306	1090	599
11:30	606	362	1230	819
12:30 PM	158	187	435	560
1:30	616	472	1730	1481
2:30	624	500	1160	694
3:30	674	520	1152	466
4:30	633	648	1020	597
5:30	550	373	902	720
6:30	707	416	865	567
7:00	2200	1401	2300	2868
8:30	175	215	405	296
9:30	374	348	460	237
10:30	92	209	313	526

(Continued)

TABLE IX (Continued)

HOURLY VARIATIONS IN BOD AND COD--RAW DATA

Time	COD (PPM)	BOD (PPM)
	Plant C	
10:00 AM	732	486
10:30	808	418
11:00	1276	627
12:00	732	352
1:00 PM	920	474
1:30	1015	472
2:00	870	470
2:30	756	365
3:00	808	352
	Plant D	
10:00 AM	1172	824
10:30	2427	1198
11:00	3556	3054
12:00	1130	676
12:30 PM	3347	1074
1:00	8577	3197
1:30	9393	>4200
2:00	>10,000	>4200
2:30	>10,000	>4200

VII. APPENDICES (Continued)

Appendix B

Detailed Data on

Gainesville Treatment Plant

TABLE X

DETAILED DATA ON GAINESVILLE TREATMENT PLANT

Sample	Ali-quots (Ml)	THURS*(Wed)5/1/58 BOD Raw (PPM)	COD (PPM)	Susp. Solids (PPM)	TUES.(Mon)5/6/58 BOD Raw (PPM)	COD (PPM)	Susp. Solids (PPM)	FRI.(Thurs)5/9/58 BOD Raw (PPM)	COD (PPM)	Susp. Solids (PPM)	TUES.(Mon)5/13/58 BOD Raw (PPM)	BOD Set** (PPM)	COD (PPM)	Susp. Solids (PPM)
(A) Plant Influent	1	747	808	498	317	815	236							
	2	544			371									
	4				375									
(B) Primary No. 1	1	457	390	96				124	134	132	351	173	631	246
	2	345						66			308	118		
	4	380						185			330	218		
(C) Filter No. 1 (through once)	1				292	589	192		345	286	557	93	676	346
	2				199			135			284	312		
	4				197			178			315	69		
(D) Filter No. 1 (through twice)	1				221	849	228	139	169	356	385	304	749	402
	2				274			222			275	134		
	4				218			185			364	277		
(E) Primary No. 2	1	374												
	2	345												
	3	313												

* The name of the day given in parenthesis is the day on which the sample was obtained; the analyses were made on the following day.

**The column of BOD values marked (set) were obtained after settling the sample for one hour in the laboratory.

(Continued)

TABLE X (Continued

DETAILED DATA ON GAINESVILLE TREATMENT PLANT

Sample	quots (Ml)	THURS*(Fri)5/16/58 BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	TUES.(Mon)5/20/58 BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	FRI.(Thurs)5/23/58 BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	FRI.(Thurs)5/30/58 BOD Raw (PPM)	BOD Set (PPM)**	COD (PPM)	Susp. Solids (PPM)
(A) Plant In-Fluent	1	474	276	840	280					190	176	405	256	566	474	628	186
	2	335	329							252	125			417	306		
	4	408	301							276	177			355	245		
(B) Primary No. 1	1	402	248	528	152	668	446	228	180					518	532	562	120
	2	371	271			549	358							411	391		
	4	343	269			323	384							373	309		
(C) Filter No. 1 (through once)	1	236	211	360	142	281	198	383	100	251	197	384	70	530	395	678	286
	2	308	237			259	206			237	176			359	225		
	4	281	234			234	173			166	170			293	184		
(D) Filter No. 1 (through twice)	1	250	110	400	192	203	106	377	200					508	391	595	220
	2	223	167			250	163							354	251		
	4	270	169			246	152							301	179		

* The name of the day given in parenthesis is the day on which the sample was obtained; the analyses were made on the following day.

** The column of BOD values marked (set) were obtained after settling the sample for one hour in the laboratory.

(Continued)

TABLE X (Concluded)

DETAILED DATA ON GAINESVILLE TREATMENT PLANT

Sample	Aliquots (Ml)	TUES*(Mon)6/3/58 (9 P.M.) BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	TUES(Mon)6/10/58 (9 P.M.) BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	FRI(Thurs)6/13/58 (9 P.M.) BOD Raw (PPM)	BOD Set (PPM)	COD (PPM)	Susp. Solids (PPM)	TUES(Mon6/17/58 (A.M.) BOD Raw (PPM)	BOD Set (PPM)**	COD (PPM)	Susp. Solids (PPM)	OVERALL AVERAGE BOD Raw (PPM)	BOD Set (PPM)
(A) Plant Influent	1	702	350	1020	404	260	157	750	304	386	194	702	224			924	336	406	254
	2	540	311			390	152			334	222								
	4	1242	313			375	273			317	188								
(B) Primary No. 1	1	422	256	776	204	398	230	794	276	305	220	463	168			718	184	365	286
	2	403	244			544	359			262	247								
	4	377	241				306			283	195								
(C) Filter No. 1 (through once)	1	134	110	343	80					190	78	287	722					247	180
	2	106	81							150	82								
	4	129	98							125	43								
(D) Filter No. 1 (through twice)	1					130	27	464	136							389	92	265	179
	2					224	130												
	4					320	130												
(E) Primary No. 1	1									236	246	471	74			752	188		
	2									235	203								
	4									238	161								
(F) Filter No. 2 (through once)	1									91	107	263	72			374	92		
	2									62	48								
	4									119	51								

* The name of the day given in parenthesis is the day on which the sample was obtained; the analyses were made on the following day.

** The column of BOD values marked (set) were obtained after settling the sample for one hour in the laboratory.