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CHEMICAL AND BIOLOGICAL TREATMENT OF PIGGERY WASTEWATERS**

The initial results of work on the treatment of piggery wastewaters from very large industrial farms are presented. Statistical analysis reveals significant variation of wastewater quantity and quality. Water flushing results in low concentration wastes not always suited for land disposal because of the large areas required. A three stage treatment system for stream discharge is investigated; consisting of sieving, chemical precipitation, activated sludge treatment followed by polishin flooded anaerobic biofilters and/or soil filtration. Detailed analysis of unit processes performance reveals the following removals: 22% tot. BOD_5 – screens; 40% tot. BOD_5 – coagulation; 92% sol. BOD_5 – activated sludge; 50% tot. BOD_5 coke biofilters. Kinetic data is developed; significant vulnerability of the bacterial activated sludge to temperature changes (teta over 1.05) is documented. The feasibility of attaining 50 mg/dm^3 and less of effluent BOD_5 in very strict operational regime is demonstrated; although the economics are questioned.

1. INTRODUCTION

The introduction of large scale animal husbandry industry in Poland has brought about a host of problems foreign to the conventional agricultural engineering concepts of land utilization of manures. The piggeries are erected usually in sizes of 12, 20, 24, 30 and 36 thousand hogs annual production and the plans foresee erection of even larger units. Units of up to 200, 000 hogs are already in operation in the Soviet Union [1]. The animal stands are water-cleaned (no bedding), and thus, rather dilute wastewaters are created containing animal feces, urine, water, disinfectants, unused fodder, etc. The character and concentration of this wastewater is such that it warrants detailed studies of its treatability for stream discharge as well as its suitability for agricultural utilization. Quantities of wastewaters produced greatly exceed the natural volumetric excretion by an animal and its basic hygienic requirements, and run usually anywhere from 20 to 40 dm^3/ /hog · d.

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In order to illustrate the irregularity of water consumption that significantly affects the dilution of an otherwise constant pollutant load, fig. 1 presents the probability of occurrence of water consumption greater than or equal to the indicated value of $dm^3/d \cdot 70$ kg hog. Such large volumes of wastewaters and the resulting significant dilutions in many cases decide against the land disposal of these wastes, requiring advanced treatment technology for stream discharge. The reasons for such an apparently costly solution usually

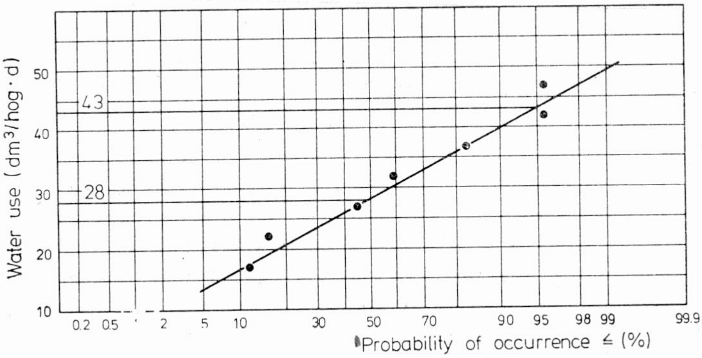


Fig. 1. Probability of occurence of unit water use at plant *D*

Rys. 1. Prawdopodobieństwo pojawiania się zużycia wody w ciągu doby na fermie *D*

lies in significant land requirements for irrigation with hog farm wastewaters. According to recommended criteria [8] a small farm of 14 thousand pigs would require over 200 ha of land if wastes are to be disposed raw, some 170 ha after solids removal, and some 35 ha if biological treatment is applied. These criteria are based on maximum nitrogen application rates of 600 kg N/ha and 20% nitrogen removal in primary treatment and close to 80% N removal in biological treatment (i.e. some 200 mg/dm^3 — N remaining).

Since the overall characteristics of the large piggery wastewaters is presented elsewhere [10], this presentation is confined to the description of a typical multistage wastewater treatment plant and analizes the performance of unit operations against the optimum expected efficiencies.

2. WASTEWATER CHARACTERISTICS

Rather irregular cleaning and feeding procedures result in daily, weekly and even seasonal variations in wastewater quality and quantity. Figure 2 illustrates the BOD_5 and COD variability in raw wastewaters in a half-year of studies at plant *A*. The inset (in fig. 2) illustrates the magnitude of hourly BOD variations at another plant *B* — taken as an average from three randomly selected round-the-clock studies [3].

A statistical correlation of basic parameters in raw and treated effluent from plant *A* is presented in fig. 3; while table 1 illustrates the effluent concentrations at the particular

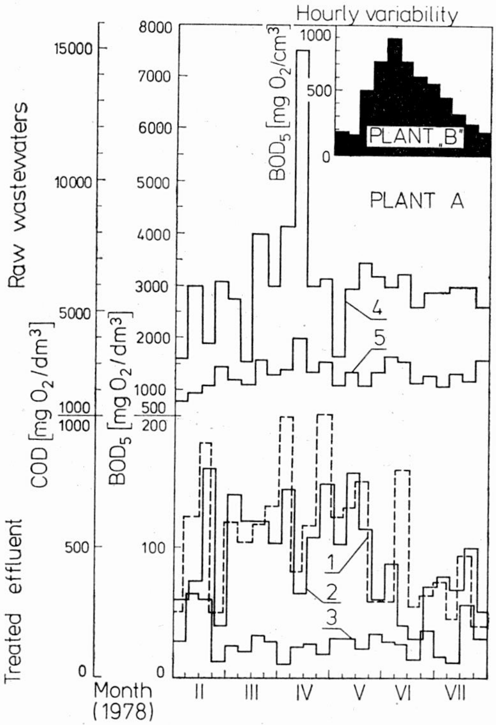


Fig. 2. Variability of COD and BOD in raw and treated effluent from plant *A*

Treated wastes: *1* – COD_{nf}, *2* – $BOD_{5,nf}$, *3* – BOD_{5f}
Raw wastes: *4* – COD_{nf}, $BOD_{5,nf}$

Rys. 2. Zmienność stężeń ChZT i BZT w surowych i oczyszczonych ściekach z fermy *A*

Gnojowica oczyszczona: *1* – przebieg zmienności ChZT gnojowicy niesączonej, *2* – przebieg zmienności BZT_5 gnojowicy niesączonej, *3* – przebieg zmienności BZT_5 gnojowicy sączonej

Gnojowica surowa: *4* – przebieg zmienności ChZT gnojowicy niesączonej, *5* – przebieg zmienności BZT_5 gnojowicy niesączonej

farm which houses close to ten thousand animals (i.e. has an annual output of over twelve thousand hogs). It should be noted here that plant *A* has been undergoing significant production changes, i.e. was stocked with small pigs, twenty kg average weight: and thus, at unchanged water use practices, the concentrations were quite low. Recently, when normal operation was resumed and all hydraulic float valves replaced water used was cut to half the previous rate.

Several correlations were found between the various parameters at all studied plants the one between COD and BOD_5, based on plant *B* sixty data points is:

$$BOD = 0.35\ COD - 1000, \quad [mg\ O_2/dm^3]. \qquad (1)$$

It should be noted that these concentrations are far below the average animal manure concentrations attained in systems prevailing in other countries where treated effluent recycle is practiced for flushing purposes and where the initial solids concentration (TS)

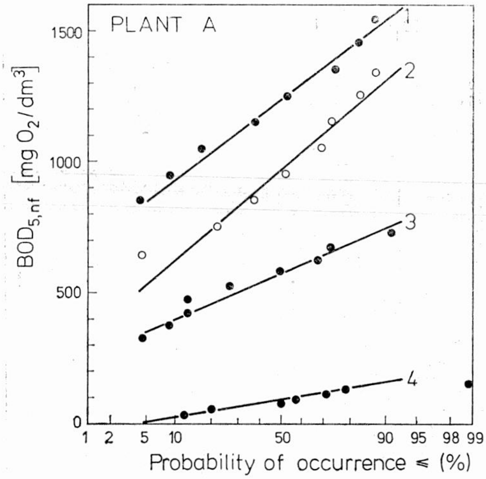


Fig. 3. Statistical correlation of raw wastes and effluents from various unit processes

1 — raw BOD_5, *2* — screened, *3* — after chemical precipitation *4* — after activated sludge

Rys. 3. Zależności statystyczne między ściekami surowymi i odpływami po różnych stopniach oczyszczania

1 — ścieki surowe, *2* — po wibrositach, *3* — po koagulacji *4* — po osadzie czynnym

Table 1

Wastewater characteristics after various treatment step — plant *A*

Charakterystyczne stężenia zanieczyszczeń po różnych stopniach oczyszczania — ferma *A*

Item	Unit	Raw wastes	Screens	Chemical precipit.	Activat. sludge	Biofilters
Average contents						
COD (O_2)	mg/dm³	5984	4160	1438	514	250
BOD_5 (*nf*)	mg/dm³	1300	1024	580	91	45
BOD_5 (*f*)	mg/dm³	n.d.	566	410	30	n.d.
Average removal						
COD	%	—	28	62	65	38
BOD_5 (*nf*)	%	—	22	39	84	51
BOD_5 (*f*)	%	—	n.d.	26	92	n.d.
TSS	%	—	23	82	n.d.	58
Process Data:						
Design		150 m³/d	2m³/m²h	5 h	48/3.5·h	sponge
Actual		320 m³/d	2·7m³/m²h	2.8 h	24/2.6·h	coke

Note: Activated sludge operated at average (design/actual) parameter ratios: MLSS — (300/2160) mg TSS/dm³; F/M — (0.20//0.35) kg BOD_5/kg MLSS · d; sludge recycle — (250/88)%. Actual,refers to the time of study.

runs above 1.5–2.5%. Such concentrations, particularly in densely populated areas without land for agricultural utilization of manure, allow for application of energy productive anaerobic digestion or liquid composting [12].

The magnitude of dilution to be expected in the practice of large farms is illustrated by plant *D* in fig. 1 where an average value is $q(50\%) = 28$ dm^3/d · hog and the design $q(95\%) = 43$ dm^3/d · hog.

Averaging the data collected by numerous authors and compiled by LOEHR [9]: 0.12 kg BOD_5/d · hog; 0.35 kg COD/d · hog; 0.121 kg SS/d · hog; 0.287 TS/d and 0.254 kg VTS/d; and compiling results of DRAGUN's work [4] and the authors' own research one obtains the basic unit raw waste load RWL from one hog — assumed to have a live weight of 50 kg. Dividing these values by the average (50%) wastewater volume output, which for plant *D* is 28 dm^3/hog · day, one obtains concentrations that compare fairly well with the data actually measured — table 2. Such an approach, favoured by the authors, allows for quick estimate of the suitability of the presented data.

Table 2

Theoretical estimation of pollutant concentrations in effluents from large piggeries and comparison with actual averages for Plant *D*

Ocena koncentracji zanieczyszczeń w odpływie ścieków z dużych ferm świń w porównaniu z aktualnymi średnimi dla fermy *D*

Pollutant	RWL (g/d·hog)			Concentration (mg/dm^3)			
	Loehr	Dragun	Authors	Loehr	Dragun	Authors	Actual
BOD_5	124	121	136	4430	4320	4860	5000
COD	352	363	400	12570	12960	14300	15000
Total solids	287	—	—	10250	—	—	12300
Volatile solids	254	—	—	9070	—	—	—
Total SS	121	—	—	4320	—	—	7700

Note: — Concentration based on $q(50\%)=28$ dm^3/d·hog
— Actual data based on 3 data point (except COD)

3. DESCRIPTION OF THE TREATMENT SYSTEM

The typical system consists of dynamic screening on vibrating — mesh 0.4 mm screens, loaded with 2–3 m^3/m^2 · h, followed by equalization designed for approx. 20 hrs (average daily flow) with aeration as agitation. Subsequently, alum coagulation is used; the dose ranging from 0.8 to 1.2 kg $Al_2(SO_4)_3$/m^3. Clarified effluent is then fed into activated sludge tanks, operating at a F/M loading of 0.4–0.5 kg BOD/kg VSS · d. The original design included also bottom-fed flooded biological filters filled with sponge, followed by chlorination. The system presented in fig. 4 includes heating of wastewaters prior to biological treatment should the temperature of wastes fall below 10°C.

Significant quantities of solids are removed from such systems. For example, plant *A* disscussed here removes some 4–5 m^3/d of screenings, which are easily dewatered and are usually hauled away for composting in dry form since the water content is 70–85%. These solids contain up to 20% of crude protein according to our analyses [2].

The massive chemical dose yields up to 30% of sludge (compared to wastewater volume) which dewaters poorly and is difficult to dispose of agriculture even in combi-

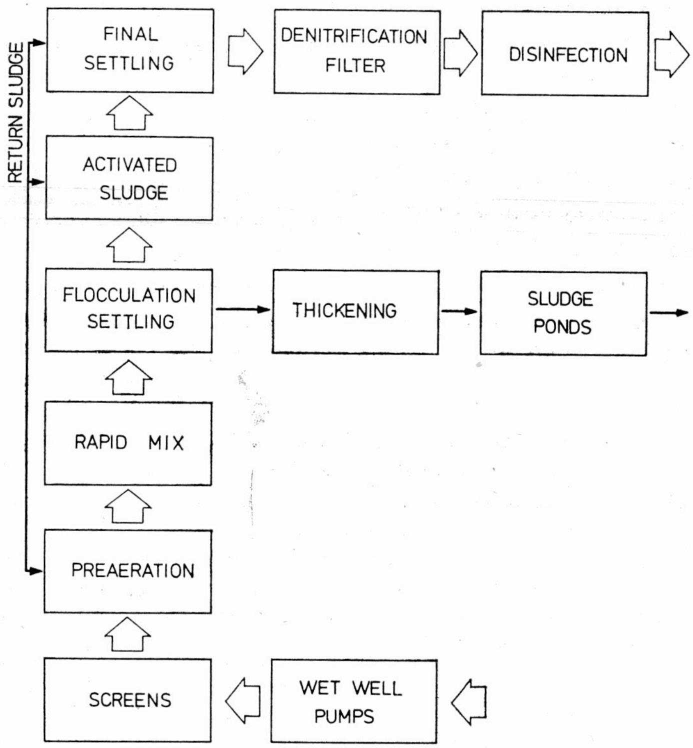


Fig. 4. Layout of a typical plant – farm *A*
Rys. 4. Schemat typowej oczyszczalni – ferma *A*

nation with excess activated sludge because of high alum content. Thus, the sludge still poses maintenance and disposal problems at the plants investigated.

4. PERFORMANCE OF THE UNIT TREATMENT PROCESSES

4.1. PHYSICO-CHEMICAL TREATMENT

The efficiency of mechanical screening at plant *A* and *C* is presented in fig. 5. It follows from this plot that average COD removal is only 10–18%, while SS removal amounts to 22%. Comparing this result with data for other plants [10], it follows that the total COD removals vary from 10 to 15%.

Full scale coagulation performed routinely in all plants of this type yields removals of total COD ranging from 40–85%, with bulk of data around 65%. Plant *A* data analysis revealed no correlation between the dose and effect, due perhaps to the changing pattern of solids discharge from the farm. Preliminary coagulation jar tests reveal an optimum dose between 0.9–1.1 kg $Al_2(SO_4)_3/m^3$, in a well defined dose – effect relationship.

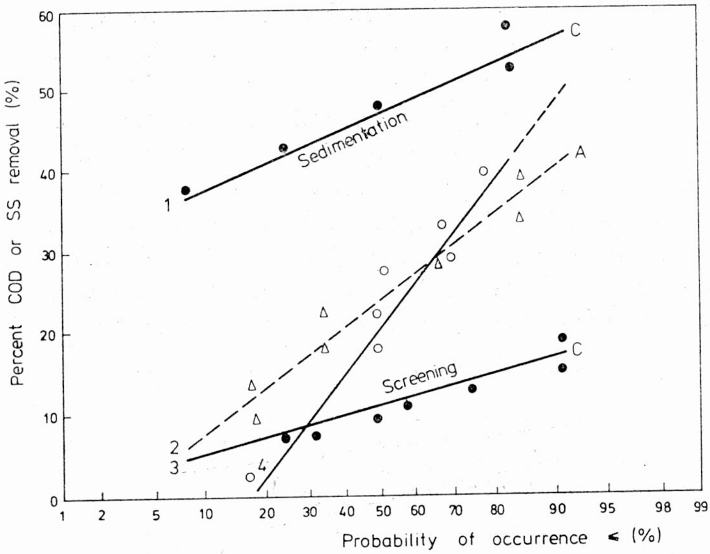


Fig. 5. Efficiency of screening at plant *A* and *C* and experimental settling tests at plant *C*:
1 — COD removal at plant *C* — settling, *2* — SS removal (*A*) — screening, *3, 4* — COD removal (plant *A* and *C*, respectively) — screening

Rys. 5. Efektywność pracy sit w fermach *A* i *C* oraz wyniki doświadczalnej sedymantacji w gnojowicy z fermy *C*
1 — obniżka ChZT — ferma *C* — sedymentacja *2* — obniżka zawiśin — ferma *A* — sita *3, 4* — obniżka ChZT (ferma *A* i *C*) — sita

Settling tests performed in laboratory on plant *A* effluent yield COD removals of 35–65% and SS removals of 50–75%; plant *C* settling tests are presented in fig. 5 (curve *1*).

A similar plot represents COD concentrations in raw effluent after screening, after chemical treatment, after activated sludge and after polishing in the rather inefficiently operating subsoil drainage field in fig. 12. The denitrifying filters are hypassed in this plant.

4.2. BIOLOGICAL TREATMENT

At plant *A* two completely mixed surface aerations were used at the time of study to treat primary effluent of an average incoming strength of 580 mg O_2/dm^3 — BOD_5. At present the concentrations have doubled, however, the retention time increased correspondingly. The design activated sludge parameters versus the actual working regime during the time of this study are presented in table 1. In reality, due to fluctuating water use at farm *A* (n.b. all farms exhibit at least 100% water consumption variability) the actual F/M, sludge age and hydraulic detention times vary somewhat due to changing hydraulic loading.

The removal efficiency in the activated sludge system depends on many direct factors, the most important being food to microorganisms ratio (F/M) or sludge loading, temperature and sludge age, i.e. the sludge recycle practices. There are also indirect factors that influence biological system performance, such as total dissolved solids (TDS), sludge volume index (SVI), zone settling velocity, etc. The effects of some of these variables on treatment efficiency of the plant *A* activated sludge system will be discussed here.

A rather well defined relationship between sludge loading and the BOD_5 removal ratio is presented in fig. 6. The F/M ratio has a pronounced effect on the effluent suspended solids carryover from the settling tank overflow. This is best exhibited by fig. 7 which illustrates the effluent BOD_5 versus BOD F/M for both soluble and the total values; similar relationships were obtained for COD data. The significance of adequate final clarification is evident from this graph. Soluble effluent BOD stays relatively unchanged

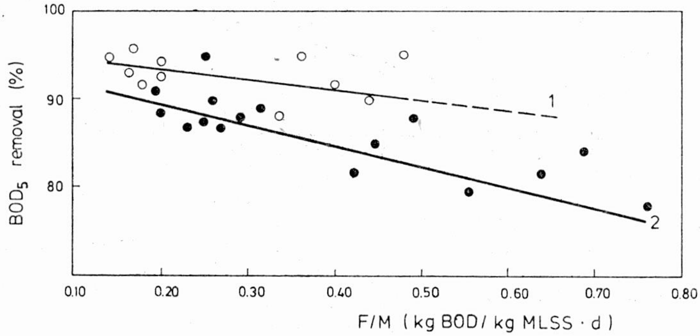


Fig. 6. BOD removal versus F/M

1 – $BOD_{5,f}$, *2* – $BOD_{5,nf}$

Rys. 6. Redukcja BZT_5 w zależności od obciążenia osadu ładunkiem zanieczyszczeń – ferma *A*

1 – $BZT_{5,sącz}$, *2* – $BZT_{5,niesącz.}$

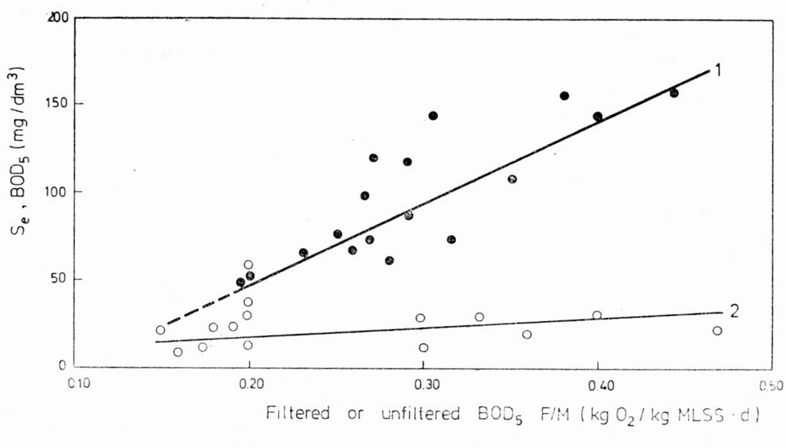


Fig. 7. Effluent BOD_5 versus F/M:

1 – $BOD_{5,nf}$, *2* – $BOD_{5,f}$

Rys. 7. BZT_5 odpływu z komory osadu czynnego w zależności od obciążenia osadu – ferma *A*

1 – $BZT_{5,niesącz}$, *2* – $BZT_{5,sącz}$.

over a large range of F/M variations, while non-filtered BOD values increase rapidly with increasing loading. This should be well substantiated by sludge volume index changes. The correlations of SVI versus F/M for both BOD and COD were however very weak. Sludge index shows a predictable significant effect on the effluent non-filtered BOD and practically no effect on the effluent soluble organics, which is at the same time indicative of the problems with sludge agglomeration. Such a relationship is presented in fig. 8.

Since all regulations on effluent concentrations are based on the total BOD_5, maintaining the appropriate sludge volume index is of paramount importance.

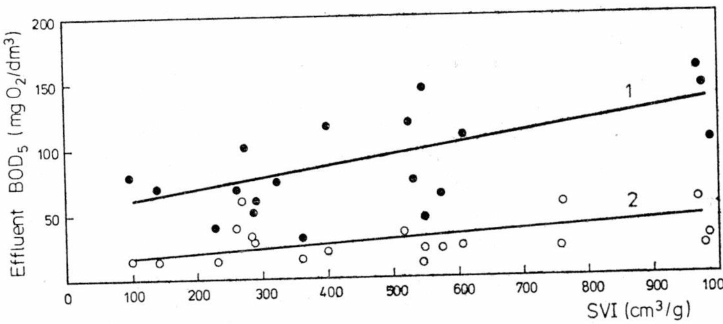


Fig. 8. BOD_5 – in biological effluent versus SVI
1 – $BOD_{5,nf}$, 2 – $BOD_{5,f}$

Rys. 8. Zależność stężenia BZT_5 w ściekach oczyszczonych od indeksu osadu – ferma *A*
1 – $BZT_{5,niesącz}$, 2 – $BZT_{5,sącz}$.

It should be noted that data interpreted here comes from plants in normal operating regime, although the authors have prepared instruction manuals for the maintenance crew (plant *A*). Thus the operating parameters varied. For instance, the influent to activated sludge tanks varied $S_{0,f} = 231\text{–}568$ mg O_2/dm^3 BOD_5, mixed liquor activated sludge solids, MLSS $X_a = 2983$ mg/dm³ and detention time $t = 0.57\text{–}1.04$ d, while temperature varied from 8–18°C.

The kinetic data for the plant *A* system is presented in fig. 9. The overall average removal rate constant for these very dilute piggery wastewaters is 3.35 d^{-1} (uncorrected for temperature). It is noted that very low excess activated sludge production was recorded, and at times no excess sludge was removed from the system. The equation used for calculation of the *K* constant is the substrate kinetic model of Grau and Eckenfelder:

$$\frac{S_0 - S_e}{X \cdot t} = K \frac{S_e}{S_0}. \tag{2}$$

The operation of the process at varying temperatures allows for estimation of the temperature correction factor for the rate constant, according to the Arrhenius equation:

$$K_T = K_{20}\Theta^{T-20}. \tag{3}$$

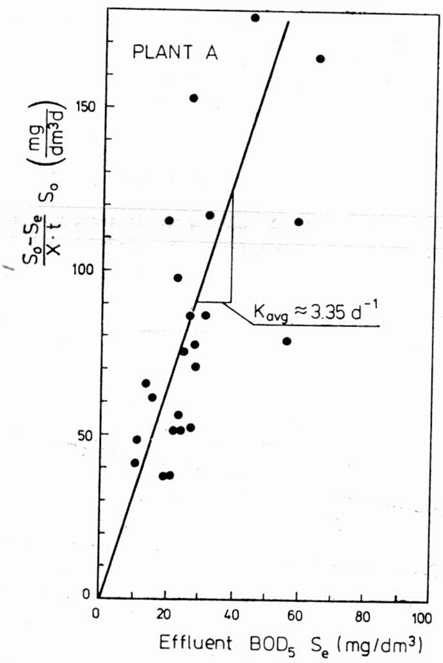


Fig. 9. Activated sludge kinetics of soluble $BOD_{5,f}$ removal
Rys. 9. Kinetyka usuwania rozpuszczonego BZT w procesie osadu czynnego

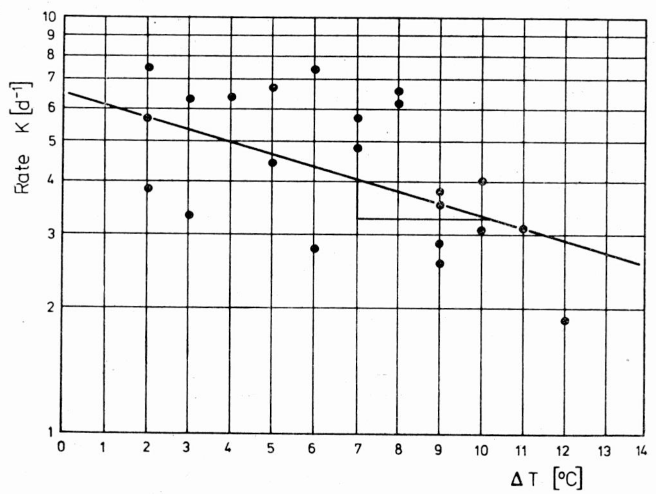


Fig. 10. Determination of the temperature correction factor for piggery wastes – plant *A*
Rys. 10. Określenie współczynnika korekty temperatury dla ścieków z fermy *A*

The plot of log K_T vs. ΔT yields log Θ = (log 4.1–log 3.3)/(11.2–7) and the value of $\Theta = 1.053$ and the average $K_{20} = 6.6$ d^{-1} — fig. 10. Judging by the spread of data the value of Θ needs further verification — it is however valid for estimation of dilute wastewaters from plant *A*.

4.3. POLISHING TREATMENT

The unstable at time operating conditions result in significant deterioration of biological effluent quality due to solids carry over. This is best illustrated in fig. 11 where effluent total BOD_5 is correlated against total suspended solids to yield:

$$BOD_{nf} = BOD_f + a \cdot SS \tag{4}$$

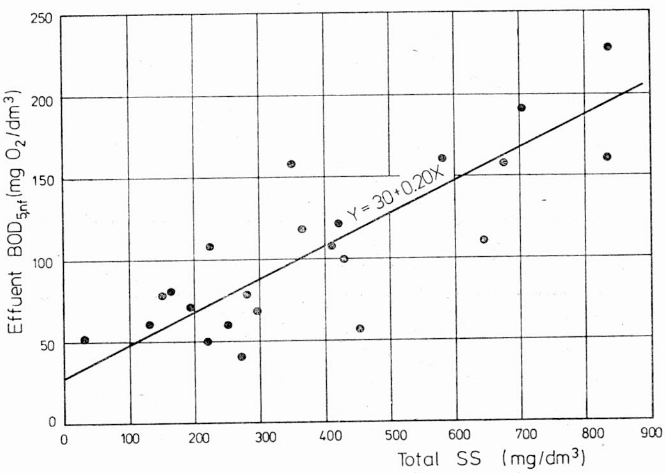


Fig. 11. Reggression of activated sludge effluent $BOD_{5,nf}$ on total effluent suspended solids
Rys. 11. Regresja BZT_5 odpływu z komory osadu czynnego w stosunku do zawiesin w odpływie

where *f* and *nf* represent filtered and non-filtered values of BOD_5, „*a*" is the slope of the curve, and SS the total suspended solids. In the case of plant *A*:

$$BOD_{nf} = 30 + 0.20\ TSS. \tag{5}$$

In order to alleviate this problem an existing (in plant *A*) anaerobic flooded biofilter has been adopted as a filtration and denitrification filter. The shall was filled with coke and in a fortnight excellent solid removals and refractory organic removals were found in the effluent. It should be stressed that the 20% participation of TSS in biological effluent is valid only for very dilute waste, such as in plant *A*. More concentrated effluents will have a ratio above 25%. The intercept, 30 mg/dm³ is the average soluble BOD (see table 1).

4.4. PROCESS EFFICIENCY

The plant *A* overall removal efficiency is presented in fig. 3 against the removal efficiency of activated sludge alone. The individual unit process efficiences are compiled in table 1 and reveal fairly predictable values, noting that these are averages of the real operating conditions without exclusion of results of routine break-ups. The data for more concentrated effluent, such as exists in plant *D* is presented in fig. 12.

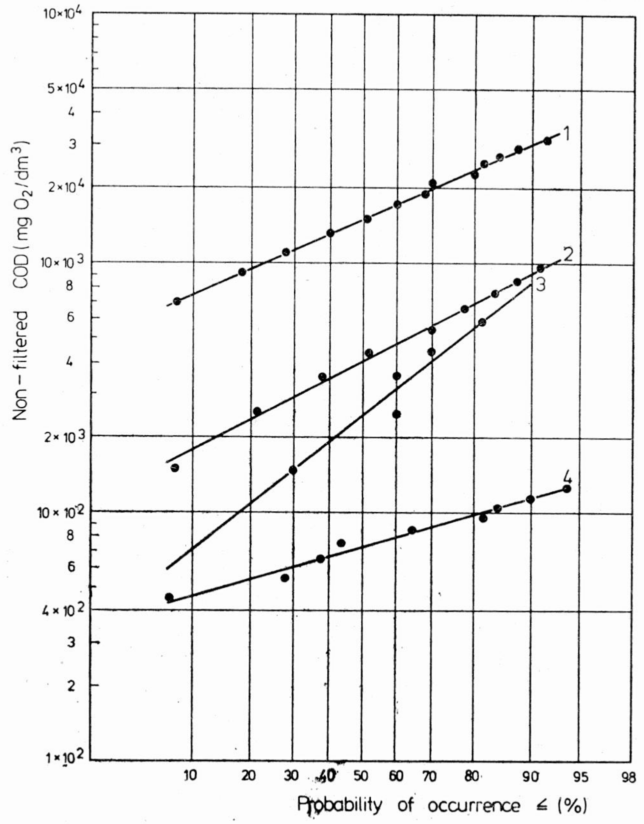
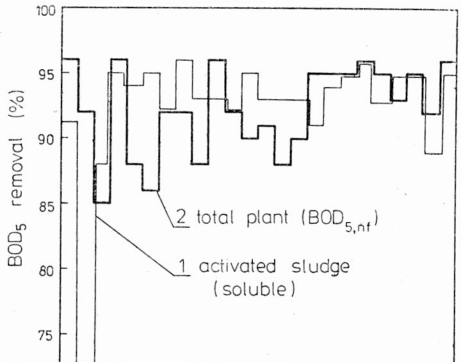


Fig. 12. Probability of occurrence of the non-filtered COD in:
1 — raw wastewaters, *2* — chemical precipitation effluent, *3* — effluent from activated sludge tanks, *4* — final effluent from drainage field — plant *D*

Rys. 12. Prawdopodobieństwo pojawiania się (ferma *D*) $ChZT_{niesącz.}$ w:
1 — ściekach surowych, *2* — odpływie po koagulacji, *3* — odpływie z pól filtracyjnych, *4* — odpływie po osadzie czynnym

It follows from this graph, when compared with fig. 3, that activated sludge is yielding poorer removals in plant *D* than in plant *A*. Analysis of plant *D* biological treatment performance revealed significant upsets of the biota, sludge index values above 600–900 (the „normal" value of SVI for pig wastewaters is 150–350) and resulting very poor solids separation. Regardless of the reasons for such a temporary situation it is apparent that in such cases the presence of chemical precipitation and additional polishing treatment steps buffers the upset of one unit process in the whole treatment train. The soluble BOD_5 values at plant *D* have varied from 60–100 mg/dm^3 ($BOD_{nf} = 75$–300) in activated sludge effluent and 25–40 mg/dm^3 in the irrigation field effluent.

The removals attained in plant *A* are well represented by fig. 13 which presents data for the total BOD_5 removal across the whole plant, soluble BOD_5 removal across the activated sludge, and documents that the plant removal is significantly influenced by the activated sludge system performance.



Month		II	III	IV	V	VI	VII
Aeration time	h	16.2	15.0	24.0	24.5	23.2	24.0
F/M	$\frac{kg}{kg\,d}$	0.40	0.37	0.32	0.52	0.29	0.24
Temp. waste/air	°C	9/1	11/1	11/6	13/9	14/12	17/16

Fig. 13. BOD removal in activated sludge (line *1*) and for the whole plant (line *2*) plant *A*:
1 – $BOD_{5,f}$, *2* – $BOD_{5,nf}$

Rys. 13. Obniżka BZT_5 w procesie osadu czynnego (*1*) dla całej oczyszczalni:
1 – $BZT_{5,sącz}$, *2* – $BZT_{5,niesącz}$

5. DISCUSSION

Large scale hog farms in this country, with hydraulic transport of manure, produce significant quantities of wastewaters that are frequently too dilute for economic agricultural utilization and highly concentrated as far as conventional treatment of stream discharge is concerned. Most of the farms seem to have expected smaller water usage and thus the treatment plants are usually hydraulically overloaded. The average water requirement is 5–7 dm^3/d · hog for consumption and basic hygiene. Standards binding design engineers propose the figure of 15 to 25 dm^3/hog · d [13] while real-life practice yields numbers as high as e.g. $q(95\%) = 40$ dm^3/hog · d. Some authors quote averages even higher: 28–45 dm^3/d · hog [14]. Efforts will now have to be made to decrease this water use by modifying the hydraulic transport system towards high pressure cleaning and wastewater recycle for flushing purposes.

The mechanical (dynamic) screening apparently yielding low solid yields (averaging 11–15% COD removal and some 20% TS) produces sludge of very good dewatering characteristics, and in all cases screens should be included in the wastewater treatment train. This is in accordance with other research findings on solid effects on treatment efficiency [5].

Coagulation is a process most difficult to assess as far as the real value of its novel position in the treatment train is concerned. The removals are relatively large. Laboratory studies conducted at this Institute [6] reveal that, at times, alum coagulation with or without cationic polyelectrolytes yields similar overflow as plain two-hour sedimentation (based on COD, SS and permanganate damand data). At higher concentrations of raw manure, when stagnating masses of solids are flushed into the sewers, coagulation yields much higher removals (by 30–50%) than plain sedimentation produces troublesome sludge. Presently, research is devoted to evaluation of the feasibility of settling (S) — activated sludge (AS) — coagulation (C) system versus the performance of the (C)–(AS) system as practiced by piggeries.

The activated sludge system is quite difficult to handle for several reasons. Plants have a relatively small primary retention volume, which at high flows decreases to less than half and influences the process loading conditions. The sludge itself is of the bacterial type as opposed to the protozoan nature of municipal sludges, and as such it has a tendency for bulking, increasing the carry-over and reducing the recycle potential. Numerous writers regard SVI = 300 as typical and characteristic for pig wastes. Our studies show that maintaining good settleability of the sludge is crucial to the process overall efficiency. Contrary to the findings of some writters [7] that it is difficult to get down to low BOD_5 concentrations in the effluent, these studies show good biodegrability of piggery effluents and rather low concentration of refractory organics. The removal rate coefficient at one plant (*A*) was found to be approximately equal to 6.6 d^{-1}. The process itself is quite temperature sensitive, the value of the correlation factor Θ (teta), equal to 1.053, is higher than that usually assumed for municipal wastes.

6. CONCLUSIONS

1. The variability of unit wastewater volume output is very significant and apparently random in manure.

2. The recommended variability coefficients i.e. daily $N_d = 1.5$ and hourly $N_h = 3$, underestimate the actual conditions. The values estimated during the authors' work were $N_d = 1\text{–}2.5$, $N_h = 3\text{–}6$.

3. The concentrations of manure should always be checked against the unit pollutant load from one hog.

4. The combined high-rate chemical and biological treatment system, such as studied here, is capable of producing high quality effluent in cases where wastewaters are diluted above the normal design conditions. In other cases, due to the complexity of the process and high strength of influent wastes, the desired value of $S_e = 50$ mg O_2/dm^3–BOD_{nf} is difficult to obtain because of: inadequate equalization, activated sludge vulnerability and bulking tendencies, solids carryover, and temperature effects.

5. Analysis of the unit process efficiences revealed that the high-rate treatment is noneconomical (power use for pumping, aeration and agitation and chemical costs).

6. Solids removal as primary treatment is essential.

7. Coagulation should be tested against plain sedimentation and longer aeration time.

8. Activated sludge is of bacterial type and quite sensitive to temperature variations:

$$\Theta = 1.053,\ K_{avg.} = 6.6\ d^{-1}.$$

9. Activated sludge solid carry-over contributes at least 20% to the total BOD_5 estimate.

10. The introduction by the authors of the coke media anaerobic (percolating) biofilters at the end of the treatment train yielded 58% TSS removal and over 50% of the total BOD_5 removal.

11. Polishing treatment is essential prior to the stream discharge of piggery effluents.

12. The research needs promulgated by this work are:

— methods of decreasing unit water demand;

— introduction of low energy–low rate treatment units;

— placing massive dose coagulation treatment in proper economical and technological perspective;

— solution of chemical and biological sludge disposal problem;

— economical recovery of products (proteins) and treated wastewater recycle for flushing;

— increasing concentration of effluents and methods of economic land application as the final disposal of effluents.

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CHEMICZNE I BIOLOGICZNE OCZYSZCZANIE ŚCIEKÓW Z TUCZARNI TRZODY CHLEWNEJ

Przedstawiono wyniki badań efektywności procesów jednostkowych, stosowanych w oczyszczalniach ścieków z tuczarni przemysłowych. Statystyczna analiza przepływów jednostkowych dowiodła, że istnieje poważna rozbieżność między praktycznym a normatywnym zużyciem wody w fermach typu przemysłowego. W związku z tym wszystkie oczyszczalnie są przeciążone hydraulicznie. Trzystopniowe oczyszczanie przed zrzutem do wód powierzchniowych składa się z cedzenia, strącania chemicznego osadu czynnego w beztlenowych złóżach biologicznych i filtracji w gruncie. Stwierdzono, że w szczególnych warunkach ściśle kontrolowanego procesu oczyszczania i szczególnie niskiego stężenia ścieków oraz obliczeniowego obciążenia hydraulicznego można uzyskać następujące efekty obniżki: cedzenie — 22% BZT_5 całk.; koagulacja 40% BZT_5 całkow.; osad czynny 92% BZT_5 rozp.; złoża — 50% BZT_5 całk. Opracowano równania kinetyczne przebiegu procesu oczyszczania i udowodniono duży wpływ temperatury na prędkość przebiegu reakcji obniżki BZT_5 rozp. (teta ponad 1,05). Przedstawiono możliwość uzyskania BZT_5 odpływu rzędu 50 mg/dm^3.

CHEMISCHE UND BIOLOGISCHE REINIGUNG VON ABWASSER AUS SCHWEINEZUCHTBETRIEBEN

Untersucht wurde die Effektivität mehrerer Grundvorgänge, die in Abwasserreinigungsanlagen von Schweinezuchtbetrieben Anwendung finden. Die statistische Auswertung des spezifischen Wasserverbrauchs ergab enorme Divergenzen zwischen den Meß-und Richtwerten. Dadurch ist die hydraulische Überlastung der ARA leicht zu erklären.

Die mehrstufige Abwasserreinigung ist in folgende Grundverfahren unterteilt: Siebvorgang, chemische Fällung, Belebtschlammverfahren, anaerobe Tropfkörper, Bodenfilter. Bei Einhaltung einer strengen und exakten Prozeßkontrolle (verdünntes Abwasser, errechnete hydraulische Belastung), sind folgende Reinigungsresultate erzielbar: (als BSB_5-Abbau): Siebvorrichtung 22%, chemische Fällung 40% (gemessen im nicht filtriertem Abwasser); Belebungsanlage 92% und Tropfkörper 50% BSB_5 des gefilterten Abwassers.

ХИМИЧЕСКАЯ И БИОЛОГИЧЕСКАЯ ОЧИСТКА СТОЧНЫХ ВОД ИЗ ОТКОРМОЧНИКА СВИНЕЙ

Приведены результаты исследований эффективности удельных процессов, используемых на очистных станциях из промышленных откормочников. Статистический анализ удельных расходов показал, что существует значительное расхождение между практическим и нормативным расходами воды на фермах промышленного типа. В связи с этим все очистные станции гидравлически перегружены.

Трёхступенчатая очистка до сброса в поверхностные воды состоит из процеживания, химического осаждения, активного ила, анаэробных биологических фильтров и фильтрирования в грунте. Выявлено, что в особых условиях строго контролируемого процесса очистки и особенно низкой концентрации сточных вод, а также расчётной гидравлической нагрузки можно достигнуть следующих эффектов понижения: процеживание — 22% общего биологического содержания кислорода (BZT_5); коагуляция 40% общего BZT_5; активный ил 92% растворенного BZT_5; слои — 50% общего BZT_5. Разработаны кинетические уравнения протекания процесса очистки и доказано большое влияние температуры на скорость проткания реакции понижения растворенного BZT_5 (Θ свыше 1,05). Показана возможность получения BZT_5 стока порядка 50 мг/дм^3.