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DYEING WASTEWATER TREATMENT BY OZONIZATION, CHLORINATION AND BROMINATION METHODS

Colour removal from dye wastewaters by a direct oxidation method using ozone, chlorine, and bromine is discussed. Results of laboratory-scale investigations obtained for dye wastewater samples containing the selected dyes, detergents and auxiliary substances are presented. For different wastewater concentration the efficiency and time of oxidation as well as doses of oxidants have been determined. Based on the results obtained the applicability and optimal conditions of the methods applied to colour removal have been established

1. INTRODUCTION

Textile industry wastewaters treatment methods for BOD_5 and suspended solids removal, employed in the sixties, have become insuficient since the textile industry wastewaters are now polluted chiefly with bio-resistant organics [4], [10]. The requirements with respect to the colour and detergents concentration in effluents discharged to surface waters have recently become more stringent. A characteristic pollution of dyeing wastes — the most burdensome group of textile wastes — is their colour. The latter is due to more and more frequently applied synthetic organic dyes which are resistant to conventional biological process of wastewater treatment [3], [6], [7], [8], [9]. Therefore there is a high demand for effective methods of colour removal from wastewaters.

2. PURPOSE AND SCOPE OF INVESTIGATIONS

The purpose of the investigations undertaken was to evaluate the usefulness of ozonization, chlorination and bromination to the treatment of textile wastewaters, in general, and to colour removal, in particular. The investigations were performed on the mixture of water solutions of dye liquors and auxiliary substances. These solutions have been conventionally called dyeing wastes. The choice of the separate groups of dyes and

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auxiliary substances has been based on the recognition of dyes employed in textile industry, as well as on the prediction for the nearest years [1], [2], [5].

The lab investigations were performed for 0.1 % and 0.5 % concentrations of dyeing wastes, (table 1). The scope of investigations has been presented schematically in fig. 1. The investigated one-state wastewater treatment processes included the application of

Table 1

Concentrations of pollutants contained in water solutions of the mixture of dyebaths and auxiliary substances

Component	Component concentration (mg/dm^3) in aqueous solutions of the dyebath mixture	
	0.1%	0.5%
Dyes		
Anilane red BLN	4.17	20.85
Lunasol rot 5 B	5.00	25.00
Sulphate brown	3.34	16.70
Welane brown	6.67	33.35
Total concentration of dyes	19.18	95.90
Auxiliary agents		
Dispersing agent NNO	2.00	10.00
Elanophore anion-active	0.33	1.65
Lodegal MK — anion-active	1.67	8.35
Rokafenol N 8 — non-ionic	0.66	3.30
Sulphanol N2	0.08	0.40
Fixing agent WOM — cation-active	6.67	33.35
Total concentration of auxiliary agents	11.41	57.05
Acetic acid	10.00	50.0
Sodium sulphide	8.35	41.75
Sodium carbonate	8.35	41.75
Sodium sulphate	8.00	40.00

ozone, chlorine water, chlorinated lime and bromine water. The effects of ozonization of pure dyes 0.005 % solutions have been determined, additionally. Moreover, the influence of pH ranging from 3.5 to 12 on the ozonization of 0.1 % dyeing wastewaters has been investigated. The pH of wastes was adjusted by applying H_2SO_4 and NaOH. Within two-step treatment 0.1 % dying wastewater was preliminary treated with lime coagulation, chlorination being used as a secondary step. The investigations were performed in two systems:

— coagulation with a selected dose of CaO and a subsequent chlorination with chlorine water,

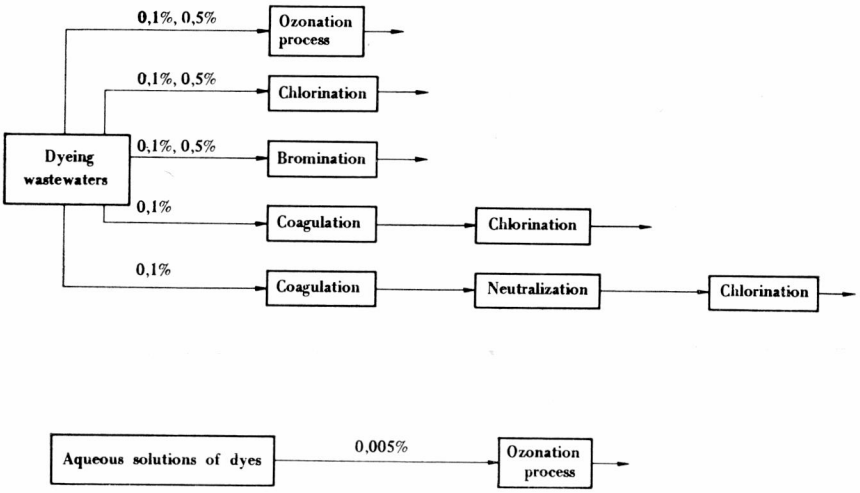

Fig. 1. Block diagrams of tested dyeing wastewaters treatment trains
Rys. 1. Schemat przebadanych technologii oczyszczania ścieków farbiarskich

— coagulation with a selected dose of CaO recarbonization with gaseous CO_2 to a neutral reaction, and then chlorination with chlorine water.

The laboratory investigations were bench scale, batch tests on samples ranging from 0.5 to 3 dm^3 at 293 K. Contact time varied from 5 minutes to 24 hours, depending on the conditions of the process. The doses of oxidants ranged within 5–1000 mg/dm^3. The effects of waste treatment were determined using the following parameters: pH, colour, COD, BOD_5 and anion-active detergents.

Ozone was produced in an ozone generator OREC in which oxygen came from the air. The rates of ozone production amounted to about 2.2 mg/min, and 9.2 mg/min, air flow rate 1 dm^3/min and pressure 20700–34500 N/m^2. Ozonization of wastes consisted in the introduction of the ozone generated in the reaction chamber. The latter was connected in series with two washers filled with the 2.5 % solution of potassium iodite. These amounts of ozone that have not been absorbed in the reactor were absorbed completely in the washers filled with potassium iodite and connected in series with the reactor. Ozone was determined by iodometric method.

Chlorination of wastes was conducted using either chlorine water or the solution of chlorinated lime containing active chlorine in concentrations of 3.5–6.0 g/dm^3.

After an adequate amount of oxidant was added the wastewater was stirred with a magnetic stirrer for a given contact time, the process was catalyzed with U. V. radiation using a quartz lamp.

Bromination of dye wastes was conducted in the same way as chlorination, bromine water contained 12.5 to 16.5 g/dm^3 of free bromine. Both chlorine and bromine were determined quantitatively by iodometric method.

The investigations on chlorination of 0.1 % dyeing wastewaters treated preliminary by coagulation method were performed as follows:

1. Wastewaters were coagulated with three doses of CaO: 150, 300 and 4000 mg/dm^3. Calcium was given in the form of lime milk containing 2 % of CaO for the dosages 150 and 300, and in a solid form for the dosage 4000 mg/dm^3.

The duration of the separate stages of the process was the following: fast stirring — 3 min, slow mixing — 20 min., and sedimentation — 120 min.

2. Wastewater being treated by coagulation was neutralized with gaseous CO_2 to the required pH value.

3. Wastewaters treated preliminarily by coagulation or by coagulation and recarbonization were chlorinated with chlorine water for 30 min. Doses of chlorine ranged from 10 to 200 mg/dm^3.

3. DISCUSSION AND RESULTS

Efficiency of the processes investigated was evaluated chiefly by using colour removal as a criterion. The remaining indices such as COD, BOD_5, anion-active detergents were determined for the selected samples and provided an additional information on processes being analyzed.

OZONIZATION

The ozonization tests of dyeing wastewaters and aqueous solutions of pure dyes have shown that the effect of colour removal is proportional to the ozonization time and to the ozone dose. These results are presented graphically in figs. 2–5. After a 30 minute

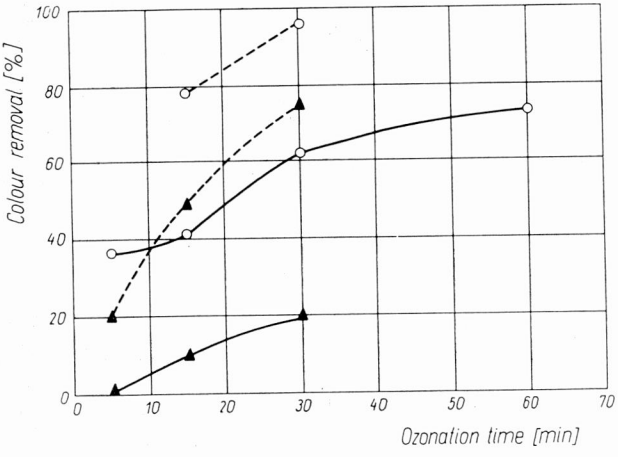

Fig. 2. Relationship between colour removal and ozonation time in dyeing wastewaters ozonation process

Dyeing wastewaters o — 0.1%, △ — 0.5%; rate of ozone production: ——— 2.2 mg/min, - - - - 8.9–9.2 mg/min

Rys. 2. Efekty usunięcia barwy ze ścieków farbiarskich w zależności od czasu ozonowania

Ścieki farbiarskie o — 0,1%, △ — 0,5%; szybkość wytwarzania ozonu ——— 2,2 mg/min, - - - - 8,9–9,2 mg/min

contact and at ozonization rate of 2.2 mg/min the colour removal in the pure dye samples ranged from 20 % to 86 %, depending on the solution examined while for 0.1 % and 0.5 % wastes it amounted to 62 % and 20 %, respectively.

These effects were greatly improved by increasing the ozonization rate to 9.9 mg/min. This refers in particular to the 0.5 % wastes for which maximal per cent of colour removal amounted to 75 %. Under the same conditions 96.5 % of colour was removed from the 0.1 % wastes (figs 2 and 3).

Ozonization of aqueous solutions of dyes has shown that the reactive dye was the most susceptible to oxidation (figs 4 and 5). The remaining three dyes, i.e. sulphuric, basic and velanic were equally removed during 30 min. oxidation. At 60 min. ozonization time colour removal for the dyes was different — the highest (78 %) being for sulphuric dye (fig. 4).

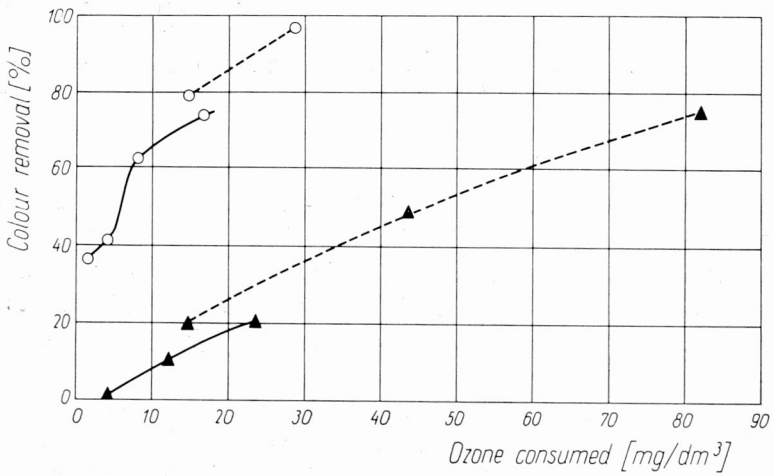

Fig. 3. Relationship between colour removal and ozone consumed in dyeing wastewaters ozonation process
Dyeing wastewater o — 0.1 %, △ — 0.5 %; rate of ozone production ———— 2.2 mg/min, - - - - - 8.9–9.2 mg/min

Rys. 3. Efekty usunięcia barwy ze ścieków farbiarskich w zależności od zużytej dawki ozonu
ścieki farbiarskie: o — 0.1 %, △ — 0.5 %; szybkość wytwarzania ozonu: ———— 2.2 mg/min, - - - - - 8,9–9,2 mg/min

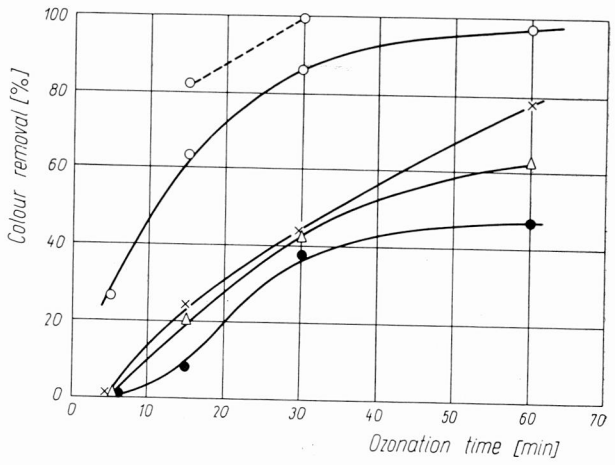

Fig. 4. Relationship between colour removal and ozonation time in 0.005 % dyes solution and ozonation process
o — reactive dye, △ — basic dye, x — sulphur dye, ● — welan dye; rate of ozone production: ————2.0–2.4 mg/min, - - - - - - - 9.2 mg/min

Rys. 4. Efekty usunięcia barwy z 0,005 % roztworów barwników w zależności od czasu ozonowania
o — barwnik reaktywny, △ — barwnik zasadowy, x — barwnik siarkowy, ● — barwnik welanowy; szybkość wytwarzania ozonu: ———— 2,0–2,4 mg/min, 9,2 mg/min

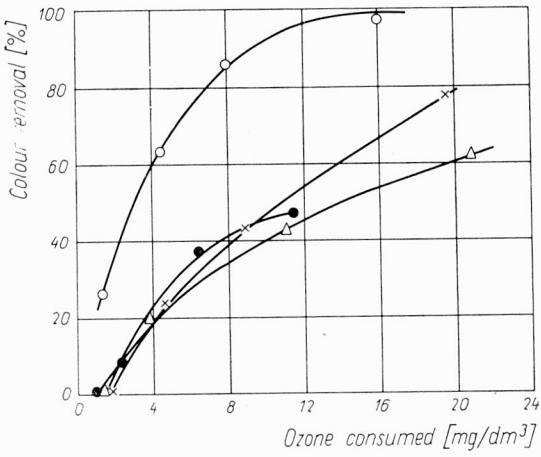

Fig. 5. Relationship between colour removal and ozone consumed in 0.005% dyes solutions ozonation process

o — reactive dye, △ — basic dye, x — sulphur dye, ● — welan dye

Rys. 5. Efekty usunięcia barwy z 0,005 roztworów barwników w zależności od zużytej dawki ozonu

o — barwnik reaktywny, △ — barwnik zasadowy, x — barwnik siarkowy, ● — barwnik welanowy

Ozone consumption index ranging within 0.10–0.33 mg O_3/mg of the dye removed confirms a high susceptibility of reactive dyes to oxidation. For the remaining dyes the indices are higher and range from 0.36 to 0.67 O_3/mg of the dye removed (table 2).

The influence of pH values on the ozonization effects have been investigated for 0.1% dye wastes. From the results obtained it follows that pH ranging from 3.5 to ca 9 does not affect the ozonization effects.

High pH values (pH 11 and pH 12) resulted in an irreversible colour removal amounting to 20% and 56%, respectively (fig. 6). After a preliminary alkalization to pH 12 the ozonization, increased colour removal by 38%, and ozonization yielding the total of 94% colour removal (fig. 6).

Ozonization of the samples investigated only slightly affected the COD values. Maximal COD removals from filtered samples were different depending on the substrate. For

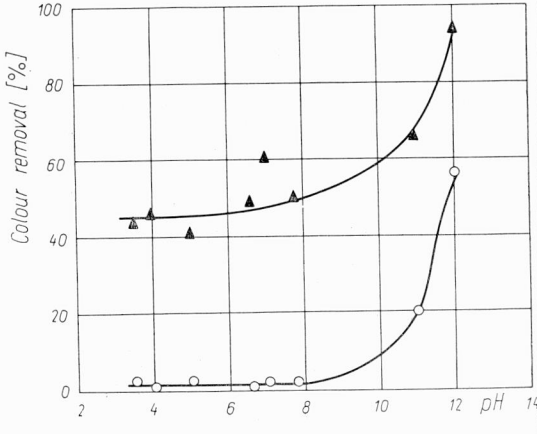

Fig. 6. Effect of pH changes on colour removal in 0.1% dyeing wastewaters ozonation process

o — before ozonation process, ▲ — after ozonation process (velocity of ozone production 2.3 mg/min)

Rys. 6. Wpływ zmian pH na efekt usunięcia barwy z 0,1% ścieków farbiarskich

o — przed ozonowaniem, ▲ — po ozonowaniu (szybkość wytwarzania ozonu 2,3 mg/min)

reactive dye solution, 0.1 % dye wastes, and 0.5 % dye wastewaters they amounted to 56.2 %, 27.3 % and 10.6 %, respectively (table 2).

For all the substrates tested the effects of COD removal during ozonization appeared to be independent of the contact time and ozone dose.

Table 2

Values of removed COD and ozone consumption index in ozonization of the investigated substrates

Substrate	Substrate concentration	COD removal from the filtered sample	Quantity of ozone used for the removal of 1 mg of dye
	%	%	mgO_3/mg
Dye wastewater	0.1	18.2–27.31	—
Dye wastewater	0.5	0–10.6	—
Aqueous solution of dyes			
— reactive	0.005	0–56.2	0.10–0.33
— basic	0.005	0–36.4	0.38–0.67
— velanic	0.005	0–4.8	0.36–0.58
— sulphuric	0.005	14.3–28.6	0.39–0.50

CHLORINATION

The rate of colour removal during chlorination with chlorinated calcium appeared to be unsatisfactory. Application of UV radiation as a catalyst allowed to shorten the reaction time from 24 hrs to 15 min.

Chlorine water gave a high per cent (99.5 %) of colour removal (fig. 8), and higher reaction rates for 0.1 % and 0.5 % of wastewaters after 30 or 60 min contact time, depending on the initial concentration of chlorine (fig. 7).

The attempt at further intensification of the process applying UV radiation as a catalyst gave positive results only with respect to 0.1 % wastes for which the reaction was reduced almost 6 times, and the colour removal appeared to depend on the duration of the process. For 0.5 % wastes such a dependence has not been found. In this case the degree of colour removal depended only on the applied dosage of chlorine (fig. 9).

It appeared that without catalyst BOD was much less dependent on chlorination than on ozonization. Maximum values of BOD removed form filtered samples amounted to 10 %. In the light-catalyzed process these values were higher and ranged from 9.5 to 21.3 % (table 3).

The changes of the remaining indices, i.e. BOD_5 and detergents did not depend on the application of a catalyst. The degree of BOD removal and that of detergents ranged within 40.2–76.9 %, and 55.0–63.3 %, respectively (table 3).

Summing up it may be stated that in chlorination of dye wastewaters colour can be removed almost entirely, however, the removal of pollutants is less effective.

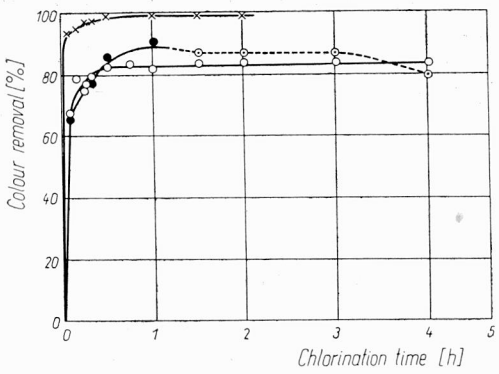

Fig. 7. Relationship between colour removal and chlorination time in dyeing wastewaters chlorination process using chlorine water as an oxidizer
dyeing wastewaters: ● — 0.1% (dosage of Cl_2 — 20 mg/dm³), x — 0.1% (dosage of Cl_2 — 50 mg/dm³), o — 0.5% (dosage of Cl_2 — 50 mg/dm³)

Rys. 7. Zależność efektu usunięcia barwy ze ścieków farbiarskich od czasu kontaktu z chlorem przy zastosowaniu wody chlorowej
● — 0,1% (dawka Cl_2 — 20 mg/dm³), x — 0,1% (dawka Cl_2 — 50 mg/dm³), o — 0,5% (dawka Cl_2 — 50 mg/dm³)

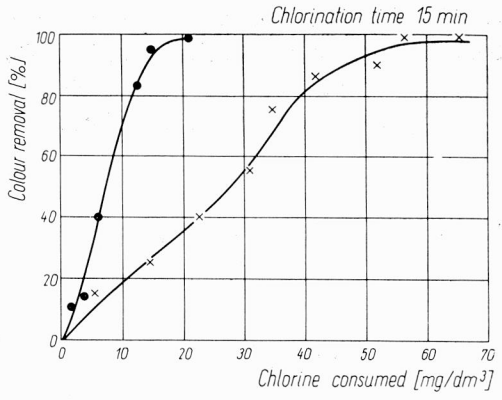

Fig. 8. Relationship between colour removal and chlorine consumed in dyeing wastewaters chlorination process
dyeing wastewaters: ● — 0.1%, x — 0.5%

Rys. 8. Zależność efektów usunięcia barwy ze ścieków farbiarskich od zużytej dawki chloru przy zastosowaniu wody chlorowej
ścieki farbiarskie: ● — 0,1%, x — 0,5%

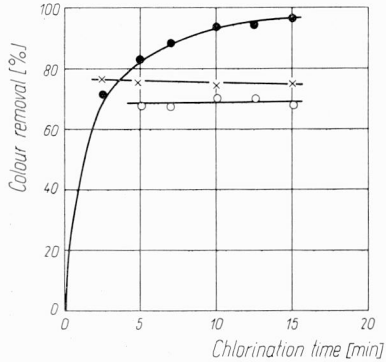

Fig. 9. Relationship between colour removal and chlorination time in dyeing wastewaters chlorination process using chlorine water as an oxiderant and UV as a catalyst
dyeing wastewaters: ● — 0.1% (dosage of Cl_2 — 20 mg/dm³), o — 0.5% (dosage of Cl_2 — 50 mg/dm³), x — 0.5% (dosage of Cl_2 — 60 mg/dm³)

Rys. 9. Zależność efektu usunięcia barwy ze ścieków farbiarskich od czasu kontaktu z chlorem przy zastosowaniu wody chlorowej i promieni UV jako katalizatora
ścieki farbiarskie: ● — 0,1% (dawka Cl_2 —20 mg/dm³), o — 0,5% (dawka Cl_2 — 50 mg/dm³), x — 0,5% (dawka Cl_2 60 mg/dm³)

COMBINED SYSTEM INCLUDING CHLORINATION

The shortcoming of chlorination with chlorine water is an acid reaction of treated wastes and the presence of free chlorine. After 24 hrs contact chlorine content amounts to about 20% of the original dose. Hence, depending on further treatment processes, the recarbonization of wastes may appear necessary.

Table 3

Selected values of the pollutants removed from dye wastewater in chlorination and bromination processes

Process investigated	Oxydant	Concentration of dye wastewaters	COD removal from the filtrated sample	BOD_5 removal	Removal anionactive detergents
		%	%	%	%
Chlorination	chlorine water	0.1–0.5	0–9.9	40.9–76.9	55.0–63.3
Chlorination + UV	chlorine water	0.1–0.5	9.5–21.3	40.2–65.8	60.0–63.3
Coagulation with CaO 300 mg/dm³ + saturation with CO_2 + chlorination with 20 mg/dm³ of Cl_2	— — chlorine water	0.1	20	—	—
Bromination	bromine water	0.1	5.2–15.9*	12.8–17.1	60.0–66.7
Bromination	bromine water	0.5	increased value of COD	27.4–35.5	50.0–60.0

*) COD removal from unfiltrated sample.

Chlorination of 0.1 % dye wastewater with different doses of chlorine at an 8 hr contact time allowed the selection of an optimal dose of chlorine, amounting to 30 mg Cl_2/dm^3. With this dosage the colour was totally removed. Concentration of the remaining chlorine amounted to 9.2 mg of Cl_2/dm^3.

COMPLEX PROCESS

Since in chlorination of dye wastewaters without a catalyst the degree of COD removal was unsatisfactory, further tests were conducted in two technological systems which incorporated chlorination as a unit process:

— coagulation with CaO and chlorination,

— coagulation with CaO, recarbonization to neutral reaction and chlorination.

Results obtained for three different doses of CaO have shown that the efficiency of colour removal from the wastewater in the second system was about 15–25 % higher (figs 10 and 11). This may be explained by the difference between chlorination rates in basic and neutral media. For the substrate investigated (0.1 % dye wastewater) it has been assumed that 300 mg of CaO/dm³ is an optimal dose for coagulation (fig. 12). For pretreated wastewater chlorination with the dose of 20 mg Cl_2/dm^3 resulted in 97 % colour remo-

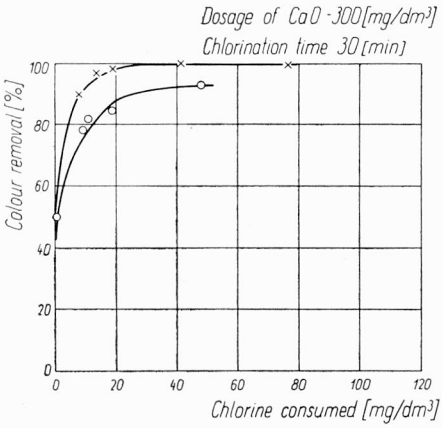

Fig. 10. Rationship between colour removal and chlorine consumed in chlorination process of 0.1 % dyeing wastewaters treated by coagulation and CO_2 saturation methods

● — dyeing wastewaters treated by CaO coagulation and chlorination using chlorine water, x — dyeing wastewaters treated by CaO coagulation, CO_2 saturation, and chlorination using chlorine water

Rys. 10. Efekt usunięcia barwy w zależności od zużytej dawki chloru w procesie chlorowania 0,1 % ścieków farbiarskich uprzednio oczyszczonych w procesie koagulacji i saturacji

● — ścieki farbiarskie 0,1 % po koagulacji CaO i chlorowaniu wodą chlorową, x — ścieki farbiarskie 0,1 % po koagulacji CaO, saturacji CO_2 i chlorowaniu wodą chlorową

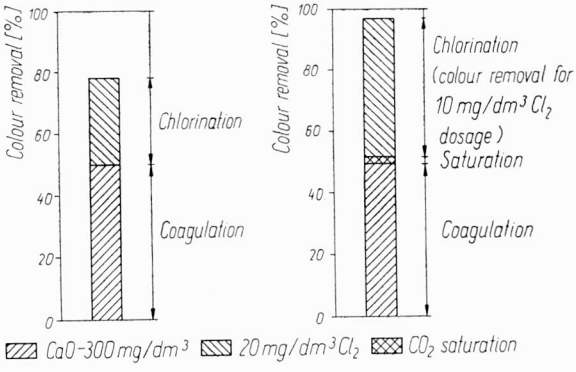

Fig. 11. Colour removal in 0.1 % dyeing wastewaters treatment process by coagulation, CO_2 saturation and chlorination methods

Rys. 11. Usunięcie barwy ze ścieków farbiarskich 0,1 % w procesach koagulacji, saturacji CO_2 i chlorowania

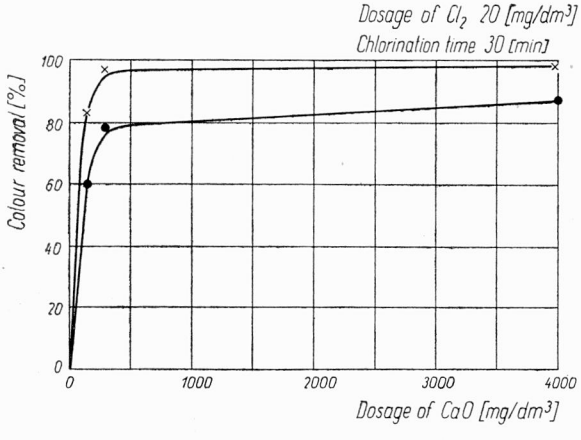

Fig. 12. Relationship between colour removal and CaO dosage in 0.1 % dyeing wastewater treatment process by coagulation, neutralization and chlorination methods

● — 0.1 dyeing wastewaters treated by coagulation using various CaO dosages and by chlorination, x — dyeing wastewaters treated by coagulation using various CaO dosages, by neutralization using CO_2 or HCl

Rys. 12. Efekty usunięcia barwy ze ścieków farbiarskich 0,1 % w zależności od dawki wapna po łącznym oczyszczaniu w procesach koagulacji, neutralizacji i chlorowania

● — ścieki farbiarskie 0,1 % po koagulacji różnymi dawkami CaO i chlorowaniu, x — ścieki farbiarskie 0,1 % po koagulacji różnymi dawkami CaO, neutralizacji (CO_2, HCl) i chlorowaniu

val and up to 20 % COD removal from the filtered sample (table 3). The chlorination alone of the untreated wastewater with the chlorine dose up to 50 mg/dm³ yielded the same degree of colour removal, though without any evidence of COD removal.

BROMINATION

Bromine was the third oxidant used to remove colour from dye wastewaters. Results of tests performed for 0.1 % and 0.5 % dye wastes have shown that this process is very fast, and takes place almost immediately after the reagents were mixed. Its degree depends solely on the dose of bromine (figs 13 and 14).

The course of colour removal is quite characteristic. The colour is not completely removed but it changes from red through orange to yellow, depending on the dosage of bromine.

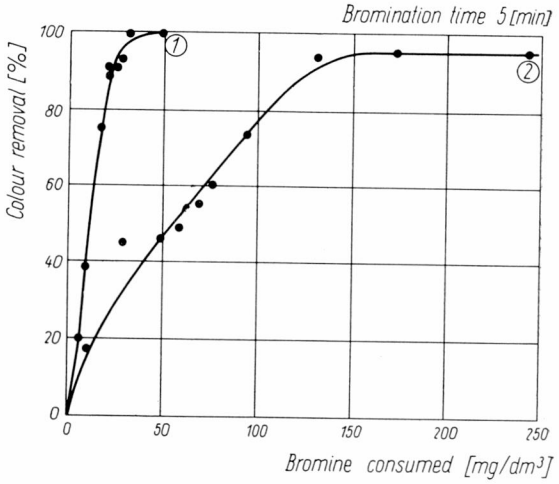

Fig. 13. Relationship between colour removal and bromine consumed in dyeing wastewaters bromination process
dyeing wastewaters: *1* — 0.1 %, *2* — 0.5 %

Rys. 13. Zależność efektów usunięcia barwy ze ścieków farbiarskich od zużytej dawki bromu
ścieki farbiarskie: *1* — 0,1 %, *2* — 0,5 %

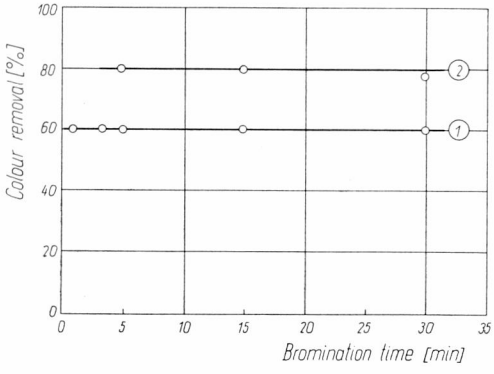

Fig. 14. Relationship between colour removal and bromination time in dyeing wastewaters bromination
dyeing wastewaters: *1* — 0.1 % (dosage of Br_2 — 40 mg/dm³), *2* — 0.5 % (dosage of Br_2 — 200 mg/dm³)

Rys. 14. Zależność efektów usunięcia barwy ze ścieków farbiarskich od czasu kontaktu z bromem
ścieki farbiarskie: *1* — 0,1 % (dawka Br_2 — 40 mg/dm³), *2* — 0,5 % (dawka Br_2 — 200 mg/dm³)

These changes give probably the evidence of the transformations occurring within chromophoric groups of dyes, being the components of dye wastes. Intermediate products of oxidation or bromination of 0.5 % dye wastewater pollutants show an increased value of COD. For the second solution investigated COD and BOD removal from the sample stirred ranged within 5.2–15.9 %, and 12.8–35.5 %, respectively, depending on waste concentration and conditions of the process. On the other hand, the removal of detergents from both solutions was the same and ranged within 50–66.7 % (table 3).

4. SUMMARY

The investigations have been conducted on dye wastewaters prepared in the laboratory. They consisted of the dyes selected from the groups that are widely applied at present and will be in the future. From the treatment of 0.1 % and 0.5 % wastewaters by ozonization method, it follows that colour removal after 30 minutes amounts to 96 % and 75 %, respectively. COD removal ranged from 0 to 27.3 %. These values have been obtained for ozonization rate equal to 9 mg/min.

Alkalization of wastewater applied prior to ozonization allowed to use about 3 times lower doses of ozone with the same effect of colour removal.

During ozonization of dyes solutions it has been stated that their degradation ability is different. Reactive dye was characterized by a high degradation ability, unlike velanic, alkaline and sulphate dyes.

Treatment of 0.1 % and 0.5 % dye wastewaters by chlorination method yielded 99.0–99.5 %, and 0–9.9 % of colour and COD removal, respectively. In case of chlorine water the rate of colour removal is higher than with chlorinated lime.

Chlorination of 0.1 % dye wastewater with 20 mg Cl_2/dm^3 during 30 min the second stage of waste treatment after lime coagulation (dose 300 mg CaO/dm^3) and recarbonization allowed 97 % colour removal and 20 % COD removal. These effects have been obtained for coagulation with 300 mg/dm^3 of CaO and consecutive neutralization with gaseous CO_2 and chlorination (20 mg Cl_2/dm^3) for 30 min.

Smaller effects of colour removal has been obtained when recarbonization step was avoided. This might be attributed to the lower rate of colour removal during chlorination in alkaline medium. The treatment of 0.1 % and 0.5 % dye wastewaters by bromination allowed to achieve 95–100 % of colour removal. Removal of COD (5–16 %) has been obtained only for 0.1 % dye wastes. The rate of colour removal is very high, and in practice the decolourization of wastes takes place immediately after the bromine water is added. This method may be applied as an emergency method of colour removal.

5. CONCLUSIONS

On the basis of the investigations conducted the following conclusions have been formulated:

Chemical or physicochemical methods are suitable for colour removal from the treated dye wastewaters.

Chlorination and ozonization methods can be used to both preliminary and final treatment of dye wastewater.

Bromination gives an immediate effect of colour removal, but because of a secondary pollution with bromine, this method is useful only in emergency treatment of dye discharges.

The simplest technological system of dye wastes treatment allowing for total colour removal and a satisfactory removal of organic substances consists of coagulation with lime, neutralization, and chlorination processes.

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OCZYSZCZANIE ŚCIEKÓW FARBIARSKICH METODAMI OZONOWANIA, CHLOROWANIA, BROMOWANIA

Praca dotyczy oczyszczania ścieków farbiarskich, a szczególnie usuwania barwy metodami bezpośredniego utleniania z zastosowaniem ozonu, chloru lub bromu. Podano w niej wyniki badań technologicznych w skali laboratoryjnej dla prób ścieków farbiarskich zawierających wybrane barwniki, detergenty i substancje pomocnicze. Określono efektywność utleniania dla różnych stężeń ścieków, czasu utleniania oraz dawek utleniaczy. Na podstawie wyników badań podano zakres przydatności badanych metod do usuwania barwy oraz określono optymalne warunki stosowania poszczególnych metod.

REINIGUNG VON FÄRBEREIABWÄSSERN MIT HILFE VON OZON, CHLOR UND BROM

Der Bericht beinhaltet die Reinigungsergebnisse von Abwässern aus Färbereien mit besonderer Berücksichtigung der direkten Oxydation mittels Ozon, Chlor bzw. Brom. Die dargelegten Ergebnisse wurden im Labormaßstab erreicht, wobei Abwässer aus Färbereien die ausgewählte Farbstoffe, Detergentien und Hilfsmittel enthielten, untersucht wurden.

Bestimmt wurde die Wirkung der Oxydation in Abwässern unterschiedlicher Konzentration, bei verschiedener Einwirkszeit und Dosen der Oxydationsmitteln. Festgelegt wurde der Bereich der Anwendbarkeit der untersuchten Entfärbungsmethoden wie auch die optimalen Bedingungen für diese Verfahren.

ОЧИСТКА КРАСИЛЬНЫХ СТОКОВ ОЗОНИРОВАНИЕМ, ХЛОРИРОВАНИЕМ И БРОМИРОВАНИЕМ

Обсуждается вопрос очистки красильных сточных вод, особенно же удаления краски непосредственным окислением с применением озона, хлора или брома. Приведены результаты технологических испытаний в лабораторном масштабе для красильных водосточных проб, содержащих определенные красители, детергенты и вспомогательные вещества. Определена эффективность окисления для разных концентраций стоков, продолжительности окисления и доз окислителей. На основе результатов испытаний определена пригодность примененных методов для удаления красок и указаны оптимальные условия применения отдельных методов.