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ON THE TREATMENT OF WASTEWATERS FROM A STAND FOR FREIGHT CAR WASH

Physical-chemical methods have been selected for the treatment of wastewaters and the disposal of sludges generated during freight car wash. The wastewaters in question are highly concentrated; they show an alkaline pH and markedly high contents of lubricating oils and greases. The highest removal of pollutants is achieved in the following system: filtration on the coke bed, neutralization with dipping acid, polyelectrolyte-aided coagulation, and chemical precipitation. The sludges produced in the treatment process exhibit a high calorific value and can be used for combustion purpose.

1. INTRODUCTION

Wastewater problems dealt with in the washing of goods wagons are as old as freightage by railway. The problem is well understood and enhances serious interests but, in fact, it has not been solved satisfactorily so far. Although a number of reports and patents concerning treatment methods for washing stand discharges have been issued [1–7], they refer to car wash in garages, to tanker cistern wash or related servioes. Up till 1980, the problem of treating wastewaters discharged from washing stands for freight car running gears has not been reported in the available literature even once.

The objective of the experimental study presented in this paper was to determine treatment methods (both economic and effective) for wastewater discharges from goods wagon runnig gear wash.

2. CHARACTERIZATION OF THE WASTEWATER

The wastewaters used in the experiments were generated during washing of running gears for goods wagons. The washing stand is operated by a rolling stock repair facility. Prior to the washing procedure, the wagon unit is subject to

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mechanical treatment in order to scrape the dirt off the surface. The washing process is carried out at a temperature between 343 and 358 K, and involves either soda lye or Rumil. Rumil is the brand name of a washing agent which consists of sodium hydroxide (about 54%), sodium metasilicate (about 38%), and sodium phosphates (about 8%).

The washing agent flows down into a collecting tank in which it is passed through a filter medium, heated to the temperature required, and recirculated. In the rinsing procedure involved water used for rinsing is collected in another compartment of the same tank and recirculated. Once a week the tank is cleaned and the wastes of about 15 tons gathering there are disposed off on a landfill.

These wastes consist of spent washing water, rinsing water, and solids from the scraping procedure. They are characterized by an alkaline pH and very high concentrations of the following pollutants: permanganate COD, dichromate COD and BOD_5. They also contain lubricating oils and greases (tab. 1).

Table 1

Physical-chemical composition of experimental wastewater

Pollutant	Unit	Soda-lye containing wastes	Rumil containing wastes
Colour	g Pt/m^3	50,000	40,000
pH	pH	12.5	11.3
Alkalinity (phenolphthalein)	g $CaCO_3/m^3$	43,000	60,850
Alkalinity (M)	g $CaCO_3/m^3$	65,500	88,850
Permanganate COD	g O_2/m^3	3,200	7,500
BOD_5	g O_2/m^3	3,740	8,400
Dichromate COD	g O_2/m^3	15,420	21,425
Chlorides	g Cl^-/m^3	600	600
Sulphates	g SO_4^{-2}/m^3	425	2,100
Organic nitrogen	g N/m^3	75	70
Ammonia nitrogen	g N/m^3	1,680	672
Dry residue	g/m^3	97,406	164,220
Total dissolved matter	g/m^3	85,782	161,620
Mineral dissolved matter	g/m^3	70,843	101,492
Phosphates	g/m^3	635	13,612
Phenols	g/m^3	12	10
Surfactants	g/m^3	3	28
Greases	g/m^3	–	1,900
Silica	g/m^3	–	3,307

3. EXPERIMENTAL

Filtration was applied to remove lubricating oils and greases. The wastewater was passed through a coke-bed filter at various filtration rates.

Table 2

Composition of raw wastewaters after neutralization with H_2SO_4

Type of wastewater	Alkalinity g $CaCO_3/m^3$	Alkalinity removal %	Permanganate COD g O_2/m^3	Permanganate COD removal %	Dichromate COD g O_2/m^3	Dichromate COD removal %	BOD_5 g O_2/m^3	BOD_5 removal %
Soda-lye containing wastes	65,500	74.5	3,200	18.7	15,420	15.3	–	–
Soda-lye containing wastes after neutralization	16,700		2,600		13,060		–	
Rumil containing wastes	88,850	87.5	7,500	62.7	21,425	49.5	8,400	40.5
Rumil containing wastes after neutralization	11,100		2,800		10,821		5,000	

Raw wastewaters were neutralized with dipping acid. As a result, large volumes of sludge were precipitated. The sludge volume depends both on the time of thickening and pH (fig. 1). The composition of the neutralized wastewater is given in tab. 2.

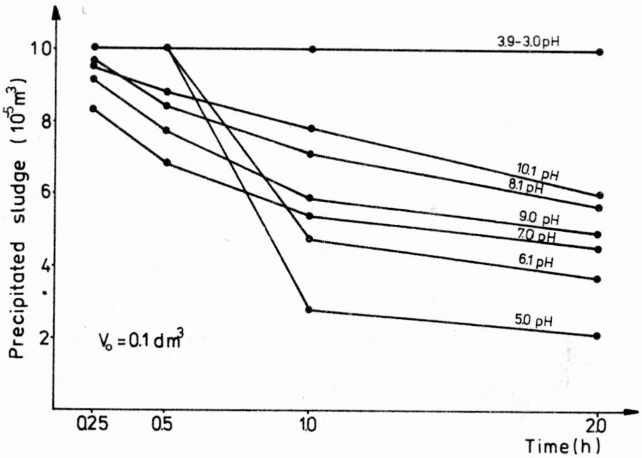

Fig. 1. Sludge volume versus time of thickening and pH

Chemical precipitation was carried out with the addition of saturated $CaCl_2$ solution. Addition of $CaCl_2$ accounts for the precipitation of very large amounts of sludge and leads to a decrease of coloured matter. The precipitation process involved various $CaCl_2$ doses. As soon as the sludge had been removed, the effluent was subject to analysis. The results are given in fig. 2.

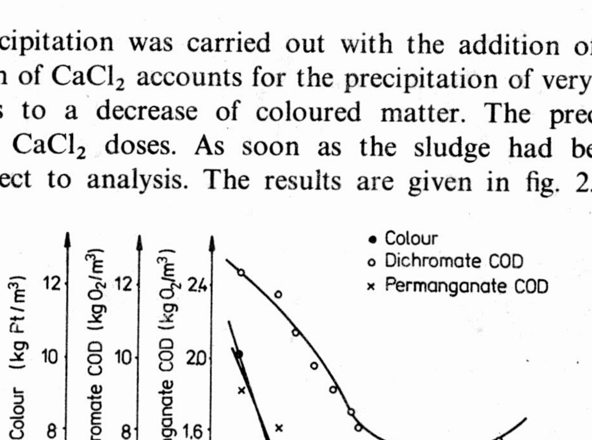

Fig. 2. Effect of $CaCl_2$ dose on the removal of pollutants from raw wastewater

The precipitation process was followed by coagulation in order to improve the removal of pollutants. $Al_2(SO_4)_3 \cdot 18H_2O$, $Fe_2(SO_4)_3 \cdot nH_2O$, and $FeCl_3$ were used as coagulants, Rokrysol WF-1 and WF-3 being applied as coagulant aids. The effect of the coagulant dose on permanganate COD and coloured matter removal is shown in fig. 3 and fig. 4, respectively.

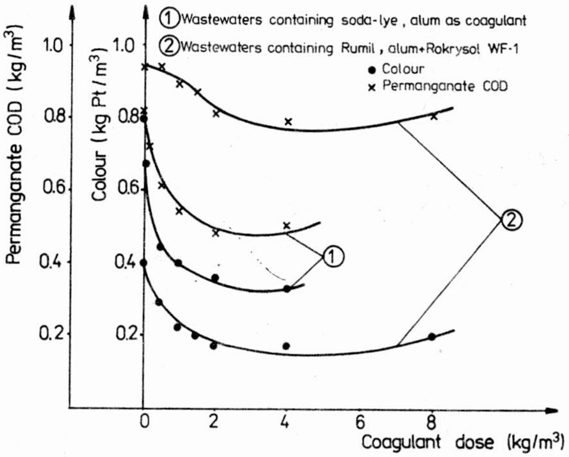

Fig. 3. Effect of coagulant dose on the removal of permanganate COD and colour from wastewaters after chemical precipitation of admixtures

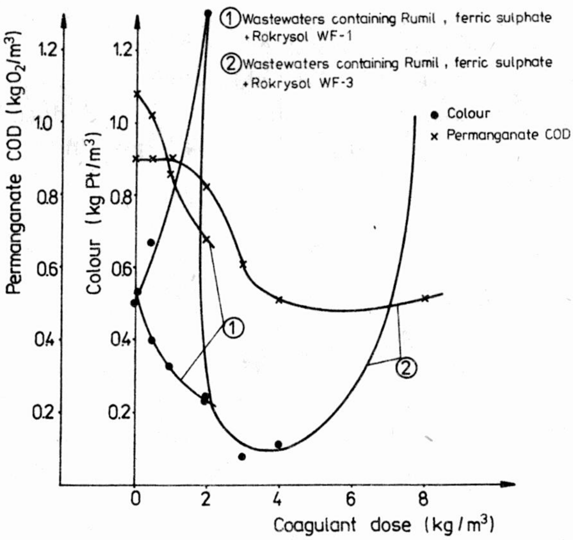

Fig. 4. Effect of coagulant dose on the removal of permanganate COD and colour from wastewater after chemical precipitation of admixtures

Coagulation was also carried out for the pollutants contained in raw wastewaters, and involved the same process parameters. The results are shown in fig. 5.

It has already been mentioned that in the treatment process large amounts of sludge are produced. The sludge itself raises serious disposal problems. Some part

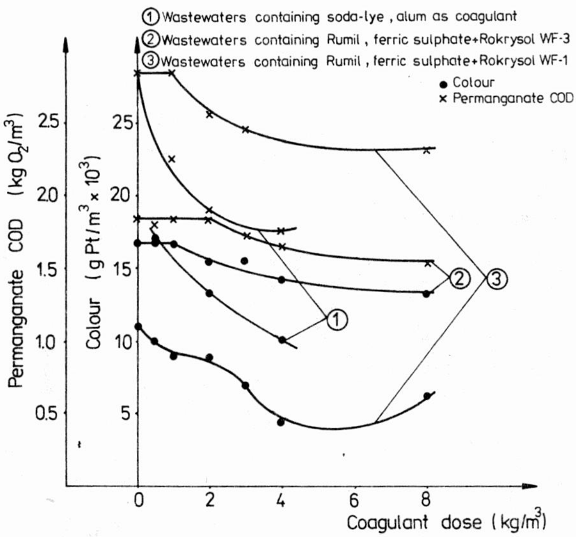

Fig. 5. Effect of coagulant dose on the removal of permanganate COD and colour from raw wastewaters

of the sludge owes its origin to the sedimentation process and consists predominantly of organic substances (tab. 3). This sludge was subject to combustion, and its calorific value was determined. But sludge is also produced during chemical precipitation, using $CaCl_2$. The characterization of this sludge (mostly of mineral type) is given in tab. 4.

4. DISCUSSION OF RESULTS

The basic problem, dealt with in the treatment of wastewaters discharged from a washing stand for freight car running gears, is the application of adequate treatment procedures and the disposal of the sludges produced (wastewater sludge and precipitation sludge). Raw wastewaters consist of sludge and supernatant liquid, half-and-half.

Filtration on a coke filter bed was used to separate lubricating oils and greases. Coke has been selected as a filter medium, because it might be reused for heating purposes (in boiler rooms). From table 5 it is noted that when the wastes are

Table 3

Composition of raw sludges

Type of sludge	Water content %	Lubricating oils and greases %	Calorific value J/g	Calorific value of ether extract J/g	MLVSS	MLSS	VSS	Ash content
					823 K		1073 K	
Sludge from soda-lye containing wastewater after withdrawal of supernatant liquid	30.4	–	13,798	–	294.4 kg/m^3	739.0 kg/m^3	21.8	717.2
Sludge from Rumil containing wastewater	24.0	14.7	11,205	43,161	15.7%	84.3%	–	–

Table 4

Composition of sludge after chemical precipitation of admixtures

Constituent	Weight percent
Water content	76.90
Solid content	23.10
Mineral solids	94.65
Organic solids	5.35
Silica	1.30
Total oxides (iron, 0.084)	2.86
Calcium and magnesium	23.70
Phosphates	12.65
Sulphates	19.08
Carbonates	11.92

Table 5

Filtration of wastes on a coke bed

Type of wastewater	Grain size m	Filtration rate m/h	Permanganate COD g O_2/m^3 Before filtration	Permanganate COD g O_2/m^3 After filtration	Permanganate COD removal %
Rumil containing wastes (filtered)	0.0015–0.002	2	7,500	3,550	52.7
		6	7,500	4,300	42.7
Rumil containing wastes (not filtered)	0.0015–0.002	2	7,500	4,000	46.7

passed through a coke filter, some 50% of the organics are removed. Since the wastewaters in question are characterized by a high pH, they have been treated with dipping acid. The neutralization process is a turbulent one and yields large amounts of sludge. Sludges generated via this route show different thickening properties which are pH-dependent (fig. 1). The thickening properties are considered to be quite good; nevertheless, at pH 5 the thickening process is stopped. The composition of the wastewaters (after neutralization) is given in tab. 2. As it can be seen from this table, the neutralization process brings about a decrease in permanganate COD, dichromate COD, and BOD_5, especially for the wastewaters containing Rumil.

A successive step in the treatment process was precipitation with $CaCl_2$. The precipitation process also yielded considerable amounts of sludge. The $CaCl_2$ dose employed in the experiments varied from 70 to 250 kg/m^3. At an optimum dose (170.6 kg/m^3), 96% of coloured matter were removed, permanganate COD was decreased by 92%, and dichromate COD was reduced by 66%. The high removal efficiency is well enough supported experimentally to justify the use of this unit process despite the large dosage reguired.

To remove pollutants persisting in the effluent from chemical precipitation, polyelectrolyte-aided coagulation was applied as the successive step. The results are plotted in figs. 3 and 4. From the curves it follows that the best removal efficiency is achieved with $Fe_2(SO_4)_3 \cdot nH_2O$ as a coagulant and Rokrysol WF-3 as a coagulant aid.

The chemical precipitation process used in conjunction with polyelectrolyte-aided coagulation was found to yield high removal efficiencies. Thus, coloured-matter removal of 99.8 and 99.3% and permanganate COD removal of 93.3 and 85.0% have been obtained for Rumil-containing wastes and soda-lye containing wastes, respectively.

Raw wastewaters were also treated by coagulation alone, yielding low removal of pollutants (fig. 1). Coloured matter removal of 80% (to a level of 10.0 kg Pt/m^3) and permanganate COD removal of 45% (to a level of 1.75 kg O_2/m^3) have been achieved for soda-lye containing wastes with alum as a coagulant. Rokrysol-WF-1-aided ferrous sulphate coagulation in Rumil-containing wastewater yielded permanganate COD removal of 36% (to a level of 1.83 kg O_2/m^3) and coloured-matter removal of 60% (to a level of 4.44 kg Pt/m^3). Another disadvantage of this method is the high cost of the coagulant involved (4.0 to 8.0 kg/m^3).

Owing to its high calorific value (12,540 to 16,720 J/g), raw wastewater sludge can be disposed of by combustion. It is, therefore, reasonable to use this type of sludge for heating purposes (in the boiler room).

Precipitation sludge consists, in the most part, of mineral matter (tab. 4). It seems worthwhile to check by experiments whether this kind of sludge is fit for agricultural uses.

5. CONCLUSIONS

1. The removal of pollutants from secondary effluents by filtration, chemical precipitation, and polyelectrolyte-aided coagulation applied as unit processes in the treatment of wastewaters from a washing stand for goods car running gears are very high and range between 93 and 99%.

2. Chlorides persisting in residual concentrations can be made less objectionable by diluting the effluent with wastewaters generated in another department of the rolling stock repair facility.

3. Separation of lubricating oils and greases should be accomplished with the use of a filter medium characterized by a high calorific value (e.g., coke) to recover additional fuel for heating purposes.

4. Because of its calorific value, raw wastewater sludge may be used for firing boilers.

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OCZYSZCZANIE ŚCIEKÓW Z MYJNI TABORU KOLEJOWEGO

Przedstawiono wyniki badań nad fizyczno-chemicznym oczyszczaniem ścieków i unieszkodliwianiem osadów powstających w myjni taboru kolejowego. Są to ścieki bardzo stężone, charakteryzujące się dużymi wartościami pH i znaczną zawartością olejów i tłuszczów.

Największy stopień usunięcia zanieczyszczeń osiąga się w następującym systemie oczyszczania: filtracja przez złoże koksowe, neutralizacja stężonym kwasem siarkowym, koagulacja wspomagana polielektrolitami oraz chemiczne strącanie. Osady powstające w procesie oczyszczania wykazują dużą wartość opałową i mogą być wykorzystane jako dodatkowe źródło ciepła.

ОЧИСТКА СТОЧНЫХ ВОД ИЗ МОЕЧНЫХ УСТАНОВОК ДЛЯ ЖЕЛЕЗНОДОРОЖНОГО СОСТАВА

Представлены результаты исследований физико-химической очистки сточных вод и обезвреживания отложений, образующихся в моечной установке для железнодорожного состава. Это очень сконцентриованные сточные воды, характеризующиеся большими значениями pH и значительным содержанием масел и жиров. Наибольшей степени удаления загрязнений достигают в следующей системе очистки: фильтрация через коксовый биофильтр, нейтрализация сконцентрированной серной кислотой, коагуляция, вспомогаемая полиэлектролитами, а также химическое осаждение. Отложения, образующиеся в процессе очистки, обнаруживают большую теплотворность и могут использоваться в качестве дополнительного источника тепла.