Pure & Appl.Chem., Vol.52, pp.1985-1989.
Pergamon Press Ltd. 1980. Printed in Great Britain

0033-4545/80/0801-1985$02.00/0

TREATMENT AND DISPOSAL OF LIQUID AND SOLID INDUSTRIAL WASTES

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Abstract-Accounts are presented of the origin, nature, composition of wastewater and solid wastes generated in manufacturing industries. For clarifying and safe disposal of liquid and solid wastes, biological, chemical and physical methods are employed, depending upon their nature and circumstances - a discussion of which is presented. Economic compulsions and stricter legislation have led industries to develop new and improvise old production methods in order that less wastes are produced in the manufacturing processes and their low-cost disposal subsequently

1. Introduction

A production system, that from the viewpoint of environmental compatibility is not even optimal and still is oriented to the thinking categories of industrial economics, has led in parallel to the economic growth of the past decades gradually but unavoidably to a situation in which the industrial wastes remaining as residues of production processes must now be felt as a serious problem complex. These more recent perceptions also include the fact, that the measures to be taken in this connection must be related on an equal opportunity basis to the hazards that lie in excessive demands put on the regenerative ability of the life-supporting elements earth, air and water or in an expanded sense, to the limited supply of total resources available. In recent years different, concrete solutions to the problems involved have been demonstrated, so that the often used alibi of a lack of technological possibilities is no longer unquestionably valid.
In the following an attempt will be made to present in a concise form a survey of the present status of treatment and disposal processes for liquid and solid industrial wastes and to indicate some trends in this field.

2. Industrial Wastewater

2.1 Origin, Quantity and Properties

Water is used in industrial manufacturing processes not only as a transportation medium, but also as a raw material and a heat transfer medium. In this connection it becomes polluted and is discharged with or without treatment, often together with an admixture of sanitary wastes, as industrial wastewater.
Depending on its source process water contains contaminating substances in differently high concentrations; many of these substances are of organic origin, on the other hand others have toxic properties. Cooling water has a relatively high heat content that can be detrimental to the biological, chemical and physical condition of the receiving water.
The specific quantity of industrial wastewater varies within broad limits, its relevant properties also. The main factors influencing quality and quantity are the production materials, the production technology and the water quality, also the proportion of recycling, the efficiency of monitoring procedures as well as the effectiveness of the treatment facility, including the operating proficiency and similar things. As a rule industrial wastewater is "one-sided" in its composition and often contains substances that are difficult to biodegrade or that inhibit metabolism, compounds with offensive odours and larger quantities of salts. Furthermore industrial wastewater can show considerable fluctuations in respect to the amounts generated as well as to the type of the contaminants and their content in the water.
The empirical values mentioned in technical periodicals in connection with industrial wastewater are to be interpreted as statements of the dimensions involved. Concrete planning should always be based on the circumstances of each individual case, especially since the motivation to use production processes involving little or no wastewater as a result of technical considerations of the environment and the costs should gain in importance in the future.

2.2 Treatment

As a first step in the treatment of industrial wastewaters the separation of the dirty process wastewaters from the "clean wastewaters", that is cooling water, and recycling endeavours are most promising, because the total quantity of water to be cleaned can be reduced in this manner. However recycling has its limits, that are determined by the "enrichment" of foreign substances, by water losses and the like. Depending on the circumstances the recovery of certain useful substances can be of importance, for example copper and nickel from etching wastewaters, chromium from electroplating baths, phenols from coking oven wastewaters etc., in which case the economic aspects must certainly conform with the emission-reducing measures. The treatment of industrial wastewater, for which basically biological, chemical and physical methods are employed, can take place on-site or together with domestic wastewater, depending on the occasion. The latter possibility is usually preferred when dealing with organically contaminated wastewaters. In this way the satisfactory treatment of wastewaters with "one-sided" compositions can be achieved more simply and efficiently and at feasible costs.
Numerous processes exist for the individualized treatment of industrial wastewaters. Depending on the case involved these processes can involve very complicated procedures. Special problems often arise in connection with persistent organic compounds, with chlorinated hydrocarbons and with heavy metals. For eliminating toxic substances chemical precipitation, dry adsorbtion, reverse osmosis and ion exchange methods are judged to be proven alternatives.

3. Industrial Wastes

3.1 Definition of the Expression "Waste"

It is not easy to give a clear definition of the expression "waste" that does justice not only to legal but to administrative and environmentally relevant requirements as well.
A certain standardization in the interpretations existing has been brought about by the guideline of the Council of the European Community. It states that wastes are substances or objects that the owner disposes of or which he must dispose of according to existing agreements among the individual countries (Note a). As a rule wastewater sludges, when they leave the sewage plant for further treatment or disposal, and wastewater, when it is not discharged into a public sewer network or a body of water, are considered to be wastes.

3.2 Types of Industrial Wastes

In respect to their origins and the disposal possibilities in each case industrial wastes can be primarily classified in non-production-specific wastes, such as kitchen wastes, office wastes, wastes from the purchase and shipping of goods, and in production-specific wastes. In the case of production-specific wastes one differentiates between wastes that can be disposed of together with household (or domestic) refuse (for example foundry sands, ashes and slag from boiler units, wood and bark wastes) and wastes that in particular because of their nature, under cicumstances also because of their quantity cannot be disposed of together with household refuse.
To this group mentioned last, in the Federal Republic of Germany designated as "Special Wastes", belong above all wastes from the chemical, pharmaceutical and the metal processing industries, in detail for example electoplating concentrates, etching mixtures, pickling salts containing cyanides acid resins and the like. Such special wastes have been designated as "Problematic Special Wastes" because, even in relatively small quantities their toxic contents, components that present a fire or an explosion hazard or odours compounds, can be very detrimental to the life-supporting elements air, earth and water. They must be processed, combusted or stored away in facilities with far reaching safety measures.

Note a: Guid eline of the Council of the European Community (78/319/EWG-A, P. Nr. I 84 - 3 - 01.03.78, p. 3) published on 20.03.78

3.3 Disposal of Special Wastes

3.3.1 Basic Concept

In as much as the quantities involved give good reason for the technical and economic feasibility of such a procedure, special wastes are usually submitted to a primary treatment of neutralizing, detoxifying and under circumstances dewatering at the point of their origin. Otherwise special wastes are at first collected, when possible separately, at receiving points that serve in particular as storage and transit stations. When necessary conditioning also takes places at these points. Depending on the type of waste final disposal is achieved through deposition or combustion of the material concerned. Usually the waste has to be brought into a disposable condition beforehand through neutralization, precipitation, detoxifying, dewatering etc.

3.3.2 Treatment and Disposal Facilities

Because it is very difficult to come to a true prognosis as to the types and amounts of future wastes, one requirement for a special waste facility is that it be flexible in its operation and offer the possibility, when necessary through modification and expansion, of being adapted to later needs.
A complete processing facility for special wastes consists of a treatment and a disposal plant. Treatment includes detoxification, neutralization and detwatering; disposal on the other comprises combustion and deposition.

The detoxification of substances containing chromates and cyanides occurs through the addition of chemicals. The pH-value of the wastewater to be discharged after precipitating the solids is adjusted in the neutralization stage. The dewatering unit assures the reduction of sludge volumes and the following deposition of the sludges without danger for the stability of the deposition site.
Mixtures of oil and water and watery sludges are delivered to the emulsion separating unit, where for coarse separations into an oil phase, and oil-water phase and a sludge phase centrifuges or heated vessels are usually employed. The oil and sludge phases are diverted to the combustion unit, whereas the oil-water phase undergoes chemical and physical processes for breaking the emulsions.
Solvents containing halogens can lead to corrosion phenomena in the combustion unit and moreover to immission problems. For this reason it is advantageous when the treatment plant also includes a destillation unit.

A deposition site for the dumping of special wastes must meet stringent water management requirements. The ground-sill and the sides must be impervious, and the basin thus formed must be drained. The drain-off water must be treated. The deposition of the wastes is to take place in accordance with a precisely established deposition plan in which the areas assigned to each type of waste and the deposition criteria to be observed must be clearly stated. Another requirement is the fastest possible, water-impermeable covering of the wastes, in order to keep the leachate rate low. Noncombustible wastes not amenable to solidification, such as arsenic sludge, are to be deposited by imbedding them in cement. If one has to cope with the evolution of gas in the deposition mass, then suitable degasing measures are required.
For several wastes considered to be highly problematic, such as watery sludge contaminated with mercury, only the subterranean deposition in salt stocks or drilling holes comes in question.
For the combustion of special wastes that are fed into the combustion chamber in watery, sludge-like or in spadeable (compacted) or solid form the use of rotating drum ovens has been proven to be suitable. Substances foreign to air that can be found in the exhaust gases are mainly carbon dioxide, hydrogen halides, chlorine gas, sulphur and nitrogen oxides, furthermore different heavy metals also. For cleaning the exhaust gases wet scrubbers are usually employed. The disposal of the sludges resulting from this procedure can take place with less complicated techniques. As long as the end products do not consist of salts and acids foreign to seawater, the combustion at sea is considered to be a remedy, in as much as a rapid dilution of the exhaust gas components in water is desired.

TABLE 1. Examples of the Costs for the Disposal of Special Wastes

Disposal Cost Estimates		DM/t
316	mineral sludges	25 - 80
511	electroplating sludges	75 - 600
513	hydroxide sludges	50 - 250
521	acids	100 - 400
524	bases (lyes)	100 - 400
527	concentrates	250 - 600
541	mineral oils	0 - 150
542	fats, waxes	75 - 400
544	emulsions and mixtures of mineral oil products	45 - 250
547	mineral oil sludges	100 - 250
548	residues from the refining of mineral oil products	75 - 250
549	other wastes from mineral oil products	50 - 250
551	solvents and mixtures of solvents	0 - 250
553	sludges containing solvents	100 - 250
555	paints, dyestuffs, varnishes	50 - 250
559	glues, putties, unhardened resint	100 - 250
573	sludges from plastics	50 - 250
577	sludges and emulsions from rubber processing	50 - 150
941	sludges from water works	25 - 150
943	sludges from wastewater treatment	25 - 150
947	sludges from sink traps, sewers, gullies	10 - 150

The disposal costs will be determined according to the extent of the treatment and disposal processes necessary as based upon the examiniation of samples of the individual wastes. The non-binding disposal cost estimates are valid for the acceptance of the wastes at the receiving point.

+) Taken from K. Meyer "Sammelstelle und Behandlungsanlage für Sonderabfälle Duisburg-Walsum (SBW)", Müll und Abfall 11/79, p. 310 - 312, E. Schmidt Verlag Berlin

3.4 Salvaging of Industrial Wastes

Where suitable technologies and the selling prices to be realized, allow an economical recovery of useful substances from waste, in which case the savings in disposal costs most definitely can play a role, increased attention to socalled "recycling processes" can be observed. Examples are, the separate collection of wastes at their sources, the regeneration of used oil, the destillation of solvents, the processing of raw sludge to building materials, the use of metal hydroxide sludges in the manufacture of bricks and many other procedures. The trend is unequivocally more and more in the direction of utilization and is essentially promoted by the in part high expenditures for disposal, that, as can be seen from Table 1, can amount to several hundred DM per ton of weight.

4. Concluding Remarks

Industrial wastewater originates in manufacturing facilities through the use of water as a transport medium, as a raw material or as a heat transfer medium. The specific quantity arising and the kind and extent of contamination depend on the production materials, the production technology,the water quality, the degree of recycling, the efficiency of monitoring procedures, the effectiveness of the clarification plant, the quality of operation and the like, and therefore it fluctuates within broad ranges. As the first step in the treatment of industrial wastewaters the separation of the contaminated process waters from the "clean" waters, for example cooling water, and the installation of recycling systems is desirable.

For clarifying the wastewaters biological, chemical and physical methods are employed, depending on the circumstances. If feasible, the possibility of treatment together with domestic sewage is preferred in general. Persistent organic compounds, chlorinated hydrocarbons and heavy metals demand special attention. For the elimination of toxic substances chemical precipitation, dry adsorbtion, reverse osmosis and ion exchange methods are judged to be proven alternatives. In the European Community substances and objects that the owner disposes of, or must dispose of according to the agreements of individual countries are considered to be wastes from the legal standpoint. Therefore sludges that leave a clarification plant for purposes of disposal are also covered by the laws relevant for wastes.

It has become customary to classify industrial wastes primarily as production-specific and non-production-specific wastes. Production-specific wastes that, because of their nature or quantity, cannot be disposed of together with domestic refuse fall into the category "Special Wastes" in the Federal Republic of Germany.

The treatment, combustion and deposition of special wastes takes place in special facilities, where as a rule detoxification, neutralization and when necessary dewatering procedures are carried out and the wastes are then deposited in accordance with stringent water management guidelines or combusted according to immission control regulations. Brought about by economic compulsions, that partially are a result of stricter legislation, the trend in waste disposal methods is away from sole decommissioning towards efforts to salvage useful substances in the residues and to avoid the formation of wastes or at least to reduce waste quantities. In the area of production, technologies to reduce and/or avoid wastes will most certainly play a main role in the future.