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APPLICATION OF CLEAN TECHNOLOGY FOR INDUSTRIAL WASTE POLLUTION CONTROL

BY

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ABSTRACT

Due to their constituents, many industrial wastewaters are difficult to treat and pose disposal problems. It is therefore desirable to adopt cleaner technologies in the production processes. Such an approach not only lowers the production cost but also holds promise for generating less pollution. This paper discusses the use of water conservation, process and equipment modification, substitution of chemical and by-product recovery for economic and environmental benefits.

INTRODUCTION

The overall purpose of water pollution control is to protect the receiving bodies of water and to ensure that their quality is suitable for any existing and future use. Industrial wastes are amongst the major pollutants of receiving water bodies. Due to the varied nature of manufacturing processes, industrial effluents vary widely in composition and often contain toxic materials to pose serious problems towards human health, plants, animals and aquatic life. As such these must be adequately treated before the final disposal. The type and extent of the treatment largely depends upon their composition and may result in huge costs and waste of valuable raw materials. The treatment costs may however be significantly reduced and valuable materials recovered by adopting appropriate measures and clean technologies. The basic philosophy of clean technology is `to produce better while polluting less' (Roustan and Capdeville, 1989). Through clean technology is achieved a more national use of raw materials and energy at a reasonable economic cost. In addition its application holds promise for economies in wastewater treatment.

Many approaches can be adopted to combat water pollution through the use of clean technology. To this effect the foremost requirement at each industrial unit level is to reduce the quantity and strength of the wastewater being produced. In this regard conservation of wastewater and its reuse may be extremely promising as savings could be made by the reuse of treated effluents instead of fresh water. Effective control on water pollution can be made through good housekeeping, production process and equipment modifications, substitution of polluting chemicals whereas savings can be made through materials and by-products recovery. Very often the cost of additional facilities required for cleaner production processes is not excessive and in certain cases immediate recovery of investments may be expected due to enhanced production and savings made through optimization. (Roustan and Capdeville, 1989).

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This paper discusses some of the important techniques that industries may opt at their premises for an effective water pollution control.

APPROACHES

Good Housekeeping

Good housekeeping refers to tight management of industrial processes (Isaac, 1980). The purpose of good housekeeping is to minimize both waste flows and pollution load at the source and hence to lower the cost of treatment. Examples of good housekeeping include shutting off of water supply values to equipment not in use, installing automatic shut off values on hoses and supplying only the optimum amount of water to a machine. In addition spillage of water and chemicals must be avoided by taking appropriate precautions. Otherwise the subsequent hosing down of the spilled chemicals will inevitably increase the pollution lead on the treatment plant. Through proper operation and regular maintenance the incidence of leakages can also be minimized. It would also be appropriate to employ dry cleaning of the factory floors and the processing equipment instead of washing with water to greatly reduce the volume of the wastewater.

Control measures should be taken to ensure that a minimum of products is left in the vessel prior to washing down. Especially in food industry, many kinds of food are carelessly washed down the factory drain rather than being scrapped into the process vessel. Through good housekeeping such wastes may be reduced. Furthermore, care should be taken that only the required quantity of chemical solution is prepared in order to avoid the need to dispose the excess chemical solution.

In electroplating industry, by hanging the finished workpiece for a longer time above the plating bath will result in lesser volume of drag out. (Isaac, 1980). Likewise in steel mills, regular descaling of heat exchangers can result in preventing the loss of heat transfer and subsequent inefficient and excessive use of cooling water.

Segregation of Waste Streams

To facilitate the treatment and reduce the treatment costs, very often it is desirable to employ segregation of wastewaters. It will be highly appropriate to segregate toxic and organic wastes since the former would interfere with the biological treatment process. As such, plating wastes, cutting oils and chemical manufacturing waste streams should be segregated for the most suitable treatment close to the source. Often segregated streams are small in quantity and can be treated economically through batch treatment processes. Cooling waters, on the other hand, can be segregated to allow their discharge into the stream without treatment.

Water Conservation

In general, the first step in minimizing the effects of industrial wastes on receiving streams and treatment plants is to reduce the volume of wastewater. This may be achieved by

conservation of water. Being little careful, may industries can conserve water in their normal manufacturing processes. Example can be given of paper board mills which discharge 1,000 to 100,000 gallons of water per tonne of the product partially depending upon their attitude towards stream pollution problem. Similarly, through careful operation, the water consumption in a textile industry can be reduced by 50% without any drop in production (Nemerow, 1978).

The greatest manufacturing use of water is for cooing purposes. Recirculation and reuse of cooling water in many industries may constitute savings upto 90%. As such steel furnaces can reuse cooling water to quench ingots. Many industries may instal counter--current washing to reduce water consumption. In electroplating industry, the rinsing step consumes upto 80% of the total water use. Rinse waters are considerably less contaminated and as such should be recycled after treatment in the ion-exchangers to recover valuable metals which would otherwise be discarded (Tay, 1989). Such a treatment would also generate a continuous determineralized water supply available for plating rinse.

PROCESS AND EQUIPMENT MODIFICATIONS

A change in the manufacturing process may significantly ease the pollution problem. Such a change may include installation of additional equipment or modification of process equipment.

Example to this effect may be cited of the textile industry which may conserve the use of water and process chemicals through continuous dyeing system in place of a batch dyeing arrangement. To operate in batches, the chemicals which have not been taken by the fibre will be drained resulting in wastage of raw materials and increased pollution. Nowadays, especially designed washers incorporating multistage counter-current rinsing systems for washing of fabrics are available and offer better efficiency in bleaching and dyeing operations (Chiu et al, 1989). Chandak (1997) has reported the use of a better reactor design in alkyd resin manufacture in the paint industry which significantly reduced the loss of by-products.

Through process modification, it may be possible to recycle the filtered effluent or to reuse the separated materials. For example, micro-filtration technique can be employed to recover metallic particles (Al, Ag, Cu) contained in the effluent. Similarly ultra-filtration technique can be employed to recover protein by extraction in agriculture and food industries (Roustan and Capdeville, 1989).

Changes in equipment can lower the strength of the waste usually be reducing the amounts of contaminants entering the waste stream. Even simple installation of screens may prevent the loss of solid organic matter with effluent from many industries such as tanneries and tapioca starch mills (Aziz, 1990). Similarly, installation of traps in the discharge pipelines in poultry plants prevent emission of feathers and pieces of fat (Nemerow, 1978).

Substitution of Chemicals

Replacing polluting chemicals with less polluting ones in manufacturing processes, if possible, can bring significant reductions in the pollution strength of the waste streams. Many examples can be cited in support of this approach.

In textile industry, less pollution can result by the substitution of carboxymethyl cellulose for starch as the sizing agent, the use of formic acid instead of acetic acid as the neutralizing agent and replacing soap with detergent as the cleaning agent. Similarly, for colour fixation purposes, the use of sodium dichromate which is a highly toxic chemical for aquatic life and difficult to treat can be replaced with hydrogen peroxide which is much less toxic in nature and simple to treat. (Chiu et al, 1989). In taking this approach the cost of treatment can be significantly reduced.

Tanneries generally use lime and sodium sulphides for dehairing purpose. It is now known that amines and enzymes can be easily substituted to do the needful (Nemerow, 1989). In pulp manufacture, the use of sulfur under different forms is employed to chemically destructure fibre plants. The use of emerging black liquor in energy application is hindered by the presence of sulfur in it. The use of sulfur may be avoided by cooking the fibre in the presence of methanol and sodium hydroxide.

In metal processing industry, to eliminate or reduce cyanide strength, copper-cyanide plating solutions can be replaced by acid-copper solutions. Similarly $CuCN_2$ strike before the copper-plating bath can be replaced with nickle strike. (Nemerow, 1978). In the steel pickling process the use of hydrochloric acid is now preferred over sulphuric acid as it can be recovered effectively after the process (Plessis, 1983).

In certain cases dry processing may be substituted for a wet process to minimize water pollution. Isaac (1980) has reported dry cleaning of barley before it is steeped in malting to reduce pollution from suspended solids.

MATERIALS AND BYPRODUCT RECOVERY

The concept of materials and byproduct recovery must be considered by the industries as it can lead to economic gains and pollution control. Any salvaging technique enabling the wasted raw materials to be reused back in the process would result in economies. However, thorough investigation will be required to utilize the concept.

In textile industry, caustic solution are used in mercerization process to give luster to the fibre. The used solution can be recovered by evaporation or dialysis. Similarly, in factories that use only one type of dye, the surplus dye can be recovered trough the use of ultrafiltration technique and reused in the dyeing bath. The bleaching and dyeing discharge is usually hot having an average temperature between 50-60°C. Through heat exchangers, the heat energy in the wastewater can be recovered and used in the production process. It is estimated that in many cases the capital cost of installing a heat exchanger can readily be recovered within a period of months (Chiu et al, 1989).

In electroplating industry, evaporation techniques can be used to recover valuable plating chemicals, for use in plating baths. The water vapours can be condensed and returned to the rinse tank. Nemerow (1978) has reported the use of ion-exchangers to recover phosphoric acid, copper, nickle and chromium from plating solutions. Paper mills with the aid of multiple-effect evaporators can recover caustic soda from cooking liquor while paper fibres from liquid waste stream can be recovered by physical separation. In the manufacture of soap and margarine, fats can normally be removed by flotation from effluents. Chandak (1997) has reported the recovery of salts from tannery wastes, gypsum from phosphatic fertilizer units and nickle catalyst from nitrogens fertilizer units.

A classic example of byproduct reconvey can be cited of the dairy industry which treats skimmed milk with dilute acid to manufacture casein. Casein manufacturers in turn utilize their wastes to precipitate albumin. The resulting albumin waste in used in crystallization of milk sugar. The residue from the process is used for poultry feed. (Nemerow, 1978). Another example of multiple usage of waste is the sulfite waste-liquor by-products from paper mills. These are used as fuel, road binder and fertilizer and in the production of alcohol and artificial vanillin. Similarly, slaughter houses recover waste blood which is used in the manufacture of glue. Many industries now make feed and fertilizers from chicken feet and feathers and recover grease which is used to make soap (Nemerow, 1978). Yeast factories evaporate a portion of their wastes and sell the residue for cattle feed. The iron sludge generated in the paracetamol industry could be an excellent raw material for the pigment industry. (Chandak, 1997). In sugar industry, molasses can be utilized for the production of alcohol and bagasse is burnt for heat generation purposes. Likewise addition of glycerine recovery plant at a soap and oil mill has been reported by Ahmed (1989) to significantly reduce the water pollution problem.

The Pakistan Tanners Association is trying to promote the recovery of chromium sulphate from spent chrome liquor in Karachi tannery establishments (PTA, 1995). On the other hand digestion of fleshings produced in tanneries can yield glues and commercial gelatins (Ahmad, 1989).

FUTURE PROSPECTS

The above cited examples of adopting clean technology refer to some of the important industries established in Pakistan. Numerous examples of application of clean technologies that can help control water pollution from other industries are also reported in the literature for the advantage of the manufacturers.

Unfortunately, the concept of cleaner production has not been picked up despite its economic and environmental benefits. The reason to this effect include attitudinal and financial constraints, the lack of technical skills and proper guidance in implementing cleaner production and a continued emphasis on end-of-pipe treatment which, in many instances, is both expensive and complicated (Chandak, 1997). It is however, encouraging to note that development of more and more unit processes and operations is revolutionarizing the industry. In coming years biochemical technologies such as bacterial desulphurization of coal hold promise for products which could be almost free of toxic and hazardous wastes.

It is the time for environmental and chemical engineers to accept the challenge and devise production methods and techniques that are not only economical but also ensure the protection of the environment.

SUMMARY

1. Depending upon the nature of their constituents, many of the industrial wastewaters are difficult to treat and pose disposal problems.
2. To minimize the water pollution, it is often desirable to adopt clean technologies in the production processes. The approach not only lowers the production costs but also holds promise for generating less pollution.
3. Many techniques are available for effective water pollution control. These include good housekeeping, segregation of waste steams, water conservation, process and equipment modifications, substitution of chemicals and materials and byproduct recovery.
4. For reasons, the concept of cleaner production has not been picked up at large, despite its economic and environmental benefits. New technologies hold promise to be environmentally friendly and invite engineers to make advances in their application.

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