Journal of Environmental Sciences Vol. 13, No. 2, pp. 198—200, 2001

ISSN 1001—0742
CN11—2629/X

Article ID: 1001-0742(2001)02-0198-03 **CLC number**: X703 **Document code**: A

A new technology for harnessing the dye polluted water and dye collection in a chemical factory*

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Abstract: A new technology for harnessing the dye polluted water and dye collection was developed. It is based on the enhanced evaporation by using solar, wind and air temperature energy and additional heat-electric energy. It consists of four parts: (1) evaporation carrier system (evaporation carrier and frame for evaporation carrier) for polluted water; (2) polluted water circulating system (pumping-spraying-collecting); (3) heating system; (4) workshop with polluted water reservoir-tanks and rainfall prevention roof. The polluted water was (heated in case necessary) sprayed to the evaporation carrier system and the water was evaporated when it moved in the space and downward along the carrier mainly by using natural (solar, wind and air temperature energy). In case, when there is no roof for the carrier system, the polluted water can be stored in the reservoirs (storage volume for about 20 days). The first 10—25 mm rainfall also need to be stored in the reservoirs to meet the state standard for discharging wastewater. The dye may be collected at the surface in the reservoir-tanks and the crystallized salt may be collected at the bottom plate. The black-color wastewater released by the factory is no more discharged to the surface water system of Taihu Lake Basin. About 2 kg dye and 200 kg industrial salt may be collected from each tone of the polluted water. The non-pollution production of dye may be realized by using this technology with environmental, economical and social benefits.

Key words: dye polluted water harnessing; dye collection technology

Introduction

Hongsheng Chemical Factory of Xishan City is located in the Taihu Lake Basin (TLB) of China. It has one workshop for producing acidoid black and black-blue dye and acid brown dye. The factory releases two types of wastewater with volume each for 10 t/d during the first and second coupling process after salt-separation and press filtration. The wastewater has COD_{Cr} 2000—4000 mg/L and color degree 4000°. The factory should stop work, if its wastewater problem could not be solved. There are a lot of dye chemical factories in TLB. Most of them meet the similar problem. The dye polluted water has high color degree, COD and salt. Its organic salt is very difficult to be decomposed by usual chemical methods and in nature. The organic salt may increase the salinity in the surface water system. Dilution of the wastewater could not improve the situation in long-term meaning. Therefore, harnessing dye polluted water is of great importance in TLB at present.

1 A new technology-evaporation engineering (EEN) for harnessing the dye polluted water

The high quality dye was developed for preventing its decomposition. The recipes for each type of dye are different. Therefore, the biochemical methods for decomposition of different type dye should be different by using high intensity input of energy and special technology. In this process, the dye could not to be recycled as a resource.

The main principle of the new technology is mainly to use the physical approaches, but not chemical approaches; namely, to use the evaporation method. It may be named as an "Evaporation Engineering (EEN)". Emphasis are taken upon enhancing evaporation of the wastewter by using mainly the natural energy (such as solar energy, wind energy, air temperature and deficit temperature energy) with additional heat-electric energy.

The annual evaporation in TLB is about 1030 mm (evaporation rate of 2.8 mm/d; Mao, 1993). It needs 357 m^2 for evaporating water 1t per day meanly in a year. Evaporation of water occurs on the water surface. It is related with the evaporation surface, difference between the saturated vapor pressure (related with surface water temperature and salinity, shape of the surface) at the surface and the surrounding vapor pressure, diffusion coefficient, energy

* This project had obtained China Patent (No. ZL98-2-26785.1)

support for evaporation (Pu, 1994). Three measures may be used for enhancing evaporation in a limited space: (1) increasing evaporation surface by using 3-dimensional evaporation carriers and pumping-spraying system; (2) using wind, air temperature and deficit air temperature energy, to increase turbulent diffusion coefficient and thermal energy input to wastewater drops; (3) using solar energy and additional artificial heating energy to compensate the consumption of latent heat loss by evaporation.

Evaporation of wastewater may lead to increase of dye and salt concentration. The dissolved dye may be crystallized by high salinity under satisfied temperature. Finally, the industrial salt, which is used for dye separation by salt, may form crystal. The dye and salt may be collected from the surface and bottom of the reservoir-tank of concentrated wastewater by evaporation.

The evaporation is strongly related with weather condition, therefore, the reservoir-tanks for storage of wastewater should be constructed for sustainable production.

2 Construction of EEN

The evaporation engineering consists of four parts: (1)evaporation carrier system (evaporation carrier and frame for evaporation carrier) for polluted water; (2)polluted water circulating system(pumping-spraying-collecting); (3) heating system; (4)workshop with polluted water reservoir-tanks and rainfall prevention roof (Fig. 1, parts B, C are constructed in parts A and D).

Fig. 1 shows the view of EEN under construction. The evaporation carrier is made from expanded synthetic fibre. The carriers are attached on the synthetic fibre rope frame (Fig. 1. A), which is fixed on four columns of 10m high above the ground. The workshop has a square shape 20 × 20 m^2. A reservoir-tank with volume of 200 m^3 (Fig. 2 Tank A), two tanks with each volume of 10^3 (Fig. 2 Tank B, C) were constructed in the workshop with waterproof roof (Fig. 1 D). The polluted water circulating (pumping-spraying-collecting) system (B) and the heating system (C) are constructed in A and D. Two pumps and 37 spraying sets are connected by tubes (Fig. 2). The wastewater is pumped up and sprayed in the evaporation carrier system above the workshop with a space of 2500 m^3. Two combine spraying-jet systems were constructed for enhancing evaporation. The condensed wastewater after evaporation in the space falls down and moves along the roof of the workshop and is collected by a tube system leading to the reservoir-tanks. A vapor heating facility (C) was constructed in one of the tanks (Fig. 2 Tank B). The wastewater will be recycled in this system till the dye and salt may be collected manually at the tank surface and on the bottom, separately. The heating system uses the high pressure vapor generated by a boiler of the factory in case, when the air temperature and deficit temperature (high humidity) are low during night or winter for enhancing evaporation.

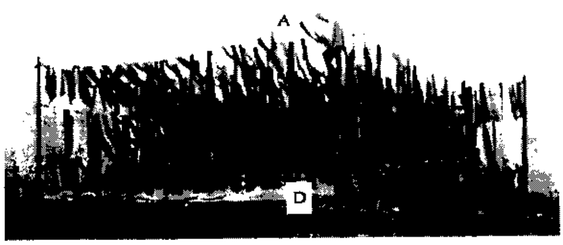

Fig. 1 The view of evaporation engineering for dye polluted water treatment

A: evaporation carrier system; D: workshop with polluted water reservoir-tanks and rainfall prevention roof; the polluted water circulating system (B) and the heating system (C) are constructed in A and D

The dye is collected in tank B, C (Fig. 2). Another reservoir-tank for saturated wastewater was constructed in the north part of workshop for collecting salt (Fig 2 Tank D). For decreasing the fee of capital construction for EEN, the roof for the carrier system was omitted. Therefore, it needs an additional management measure in case of rainfall.

3 Management of EEN

Management of EEN is essential for successful operation on treatment of the dye polluted water. The evaporation rate is strongly related with weather, pump pressure, wastewater temperature, and salinity. A meteorological observation station was established at site of EEN. The system can be operated in condition of relative humidity less than 80%—90%, if there is no heating condition. Otherwise, it may be operated during unsaturated period in relative with heated wastewater. It needs additional heat energy. We should use the natural energy for evaporation as much as possible, and regulate the operation regime according to the weather condition, the storage condition, and products demand.

After preliminary collection of dye from first coupling wastewater, the second coupling wastewater with low pH value may be mixed with the first coupling wastewater to form tenuity acid liquid (pH 6.5) for further treatment.

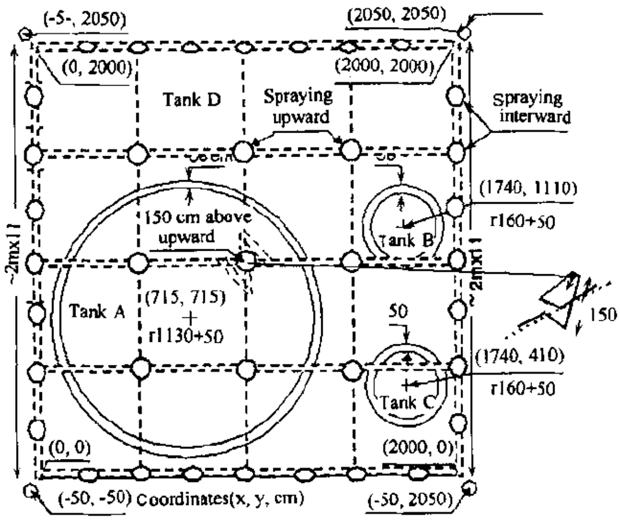

Fig. 2 Scheme of workshop area of EEN

To store the saturated (tank D in Fig. 2) and unsaturated liquid in different tanks for easier crystallizing and collecting salt and other organic and mineral salt.

The evaporation treatment should be stopped during rainfall period. According to the experimental data, the liquid returned from the roof should be collected and stored in the reservoirs in the beginning stage of rainfall 10—25 mm(4—10t) till the returned water quality better than the state standard limitation for wastewater discharge. The collected rainfall water with low COD and color may be discharged to the surface water system in TLB.

4 Capability of wastewater treatment by EEN

According to the preliminary data, the EEN technology in Xishan Hongsheng Chemical Factory, for harnessing the dye polluted water may treat 10—20 t/d in winter with additional heating, when the evaporation from a E_{601} evaporator is about 1—1.5 mm/d. It needs electricity 80—100 kWh and coal 1.5t per day. In this process the factory may get benefits of about 20—40 kg recycled dye and 200—400 kg recycled industrial salt. The capacity of wastewater treatment by EEN in summer is expected to be three times more than that in winter in TLB.

5 Potential application of EEN

The EEN technology is expected to be applied for treating non-toxic liquid, where there are enough space for the facilities, especially in arid/semiarid region. It needs to construct different EEN facilities for different kinds of dye (or other recycling matters). Construction of a roof for evaporation carrier system will improve the capacity of wastewater treatment, but needs more capital investment.

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(Received for review March 7, 2000. Accepted May 30, 2000)