Status on Radiation Treatment of Liquid Sample in Korea

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For the wastewater treatment, an electron beam pilot plant for treating 1,000m3/day of wastewater from 60,000m^3/day of total dyeing wastewater was constructed and have been successfully operated . In addition to this pilot plant study, construction of commercial scale plant for treatment of dyeing wastewater is being done under TC project organized by IAEA together with E-B Tech. Co., Ltd., Korea Atomic Energy Research Institute(KAERI) and dye wastewater treatment station in Korea. On the other hand, several studies using radiation are being carried out in the field of treatment of polluted groundwater, advanced treatment of sewage, sterilization of discharged water from sewage treatment plants. Many researches on water and wastewater treatment using radiation will be carried out under support of long term basis nuclear R&D program by government.

1. Status on the research works for the radiation treatment of water and wastewater

- Radiation technique for reuse of treated wastewater from sewage treatment plant

Treated water discharged from sewage treatment plant can be reused for the purpose of irrigation, industrial water and maintaining proper water level for river during dry season. KAERI had studied the reclamation of sewage by Co-60 for the purpose of industrial use during dry season. Color removal and COD reduction, which are well known as the most difficult factors in the reclamation of secondary effluent, were studied intensively, and disinfection with an irradiation dose was also investigated. The effect of TiO_2 addition on dose reduction was examined for comparison. The irradiation dose varied from 1 kGy to 15 kGy. The color with 19 – 28 ADMI was reduced to less than 10 ADMI at 5 kGy. COD concentration was also quickly reduced from 25 mg/l to 10 mg/l at 5 kGy. Disinfection could be also well done at 0.5 kGy. The addition of TiO_2 into the sample solution could reduce the dose to two third of that in the absence of TiO_2. Based on these experimental results, a small scale of pilot plant study with 1 m^3 /hr of treating capacity was done. Figure 1 and 2 show the view of experimental

system and result on disinfection with dose .

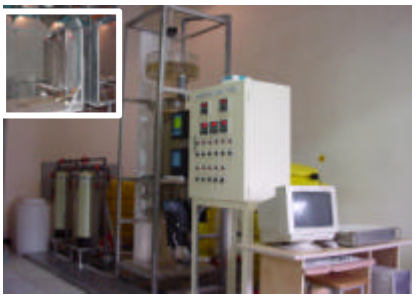

Fig.1 view of pilot plant

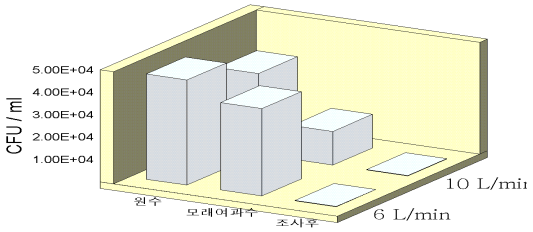

Fig.2 disinfection with dose

- **Radiation technique for treatment of groundwater polluted by organic toxic compounds**

The pollution of groundwater with chlorinated ethylenes is becoming a serious problem in industrialized areas of Korea. As a result, the government limited TCE and PCE concentrations in groundwater to less than 0.03 and 0.01 mg/L, respectively, since 1993. However, the contamination of groundwater with these pollutants did not decreased due to increasing industrialization and poor groundwater conservation. Thus, many techniques have been proposed for the reclamation of groundwater. Among them, adsorption onto activated carbon and air-stripping are found to be efficient and economic, however, they just remove the contaminants but do not destroy them.

An attractive solution of TCE and PCE pollution is radiation-induced decomposition. The organic pollutants can be completely decomposed by gamma-ray or electron-beam irradiation, and the decomposition is more efficient in the presence of O_3. Based on these situation, KAERI have carried out study on TCE and PCE decomposition by a combination of gamma-rays, ozone and titanium dioxide and a combination of gamma-rays, ozone and titanium dioxide was evaluated for efficient decomposition of TCE and PCE. Moreover, the cytotoxicity of the pollutants and their decomposition products was also investigated with Chinese hamster V79 cells. From the experiment, gamma-ray treatment in the presence of ozone (O_3) and titanium dioxide (TiO_2) showed an efficient removal of trichloroethylene (TCE) and perchloroethylene (PCE). Without gamma-irradiation, TCE and PCE were not sufficiently decomposed to comply with the water quality limit of groundwater. However, near 100 % of TCE and PCE were removed at a dose of 300 Gy in the presence of O_3 and TiO_2, where TiO_2 showed an explicit enhancement of decomposition. Cytotoxicity test using Chinese hamster V79 cells showed no toxicity of the TCE and PCE decomposition products. Figure 3 and 4 shows

the experimental systems for treatment of groundwater polluted by organic toxic compounds

Fig.3 view of experimental system for treatment of groundwater

Fig.4 view of irradiation

- **Radiation technique for sterilization of sewage**

Korea government established a new regulation related to coliform contained in discharging water from sewage treatment plant from next year. It will be more strengthened to less than 3,000/ml. Therefore sewage treatment plant should find proper techniques as soon as possible. Several plants have installed the disinfection apparatus with UV irradiation but it has been known that it is not effective when water contains the turbid materials and UV lamp should be often cleaned in order to avoid the film generation covering the surface of UV lamp. And it also needs large space for irradiation. From these kinds of problem by UV irradiation technique, an university has studied on the disinfection with an electron beam irradiation and they got valuable experimental results regarding to killing coliform. All coliforms could be killed at 0.3 kGy irradiation dose. This technique might be substitute existing conventional technique in near future.

2. Status on the field works for the radiation treatment of water and wastewater

- **Pilot plant for treatment of dyeing wastewater (1,000 m^3 /day)**

The most of textile factories in Korea are concentrated in several place and these textile factories discharge a huge amount of wastewater through proper treatment. But still it has many problems in terms of not only environmental conservation but also economical aspect. Table 1 shows the characteristics of dyeing wastewater treatment plant and representative dye industrial complex in Korea.

Table 1 characteristics of dyeing wastewater treatment plant and representative dye industrial complex in Korea

items	Banwol	Daegu	Busan
no. of factory	61	112	50
capacity for waste-water treatment	100,000 m^3/ day	85,000 m^3 / day	60,000 m^3 /day
average wastewater treatment (/m^3day)	61,800 m^3 / day	75,000 m^3/day	33,000 m^3 /day
cost (US$/m3)	0.6	1.0	0.35

An electron beam pilot plant for treating 1,000 m^3/day of dyeing wastewater from 60,000 m^3/d ay of total wastewater was constructed and has well operated in Daegu Dyeing Industrial Complex(DDIC). TDIC includes now more than hundred factories occupying the area of 600,000 m^2 with 1,300 employees in total. A majority of the factories has equipment used for dip dyeing, printing and yarn dyeing. The production requires high consumption of water (90,000 m^3 /day), steam and electric power, being characterized by large amount of highly colored industrial wastewater. Therefore, intensive and effective purification of the wastewater is one of the most complicated and actual problems of DDIC's current activities. Purification of the wastewater is performed by conventional wastewater treatment method. Current facility treats up to 78,000 m^3 of wastewater per day, extracting thereby up to 730 m^3 of sludge. Rather high cost of purification results from high contamination of water with various dyes and ultra-dispersed solids. Because of increase in products in factories and increased assortment of dyes and other chemicals, substantial necessity appears in re-equipment of purification facilities by application of efficient methods of wastewater treatment of incoming wastewater.

The studies have been carried out regarding to the possibility of electron beam application for purification of wastewater. With the co-work of E-B tech and IPC, the experiment on irradiation of model dye solutions and real wastewater sample (from various stages of treatment process) have been performed. The results of pilot plant operation showed the application of electron beam treatment of wastewater to be perspective for its purification. The most significant improvements result in decolorizing and destructive oxidation of organic impurities in wastewater. Installation of the radiation treatment on the stage of chemical treatment or immediately before biological treatment may results in appreciable reduction of chemical reagent consumption, in reduction of the treatment time, and in increase in flow rate limit of

existing facility by 30-40%. Figure 5 shows the schematic diagram of pilot plant for the treatment of dyeing wastewater. 1 MeV, 40kW electron accelerator was used for pilot plant test .

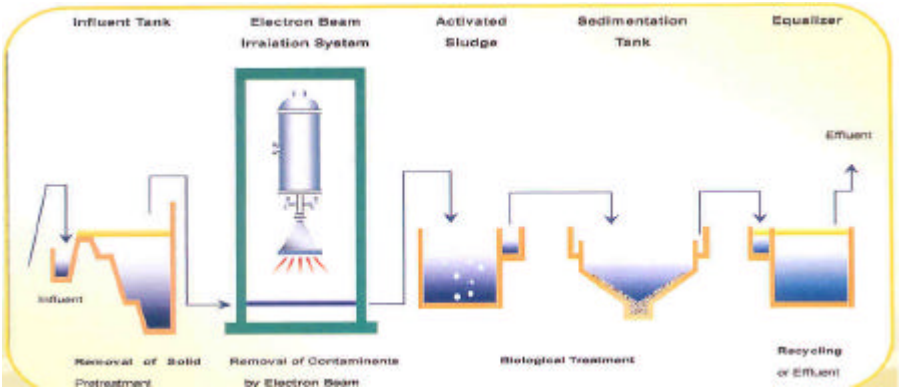

Fig. 5 Schematic diagram of pilot plant for the treatment of dyeing wastewater

- **Commercial plant for treatment of dyeing wastewater (10,000 m^3 /day)**

Construction of commercial scale plant for treatment of dyeing wastewater is being done under TC project organized by IAEA together with E-B Tech. Co., Ltd., Korea Atomic Energy Research Institute(KAERI) and dye wastewater treatment station in Korea. According to the plan, 10 MeV, 400kW electron accelerator based on the economical aspects will be used and irradiation dose will be under 1 kGy. Treating capacity will be up to 10,000 m^3 /day.

3.**Status on the radiation tools for research and field work of the radiation treatment of water and wastewater**

- **Electron beam accelerator**

Electron beam accelerator with 2 MeV installed in EB-tech. Co., Ltd., has been mainly used for study on the water and wastewater treatment in Korea. One more of Electron beam accelerator with 2 MeV and 5-10 MeV are planned to be installed in KAERI for the study on the water and wastewater treatment and other studies in near future.

- **Gamma – ray source**

Co-60 Gamma ray source with 100,000 Ci installed in KAERI has been also used for study on the water and wastewater treatment. One more of Co-60 Gamma ray source with around 1,000,000 Ci are planned to be installed in KAERI for the study on multi

purpose of research and development in near future.

4.Future prospects

According to our long term basis governmental nuclear R&D program on development of radiation technique, activities on radiation technique will be more active.

The Korea government is promoting energetically the development of radiation technology. The promotion plan for utilization of radiation and radioisotope has been established very recently by MOST. According to the plan, 30% of nuclear R&D budget shall be devoted to the development of radiation technology. A new "Research Center for Advanced Utilization of Radiation" is being constructed, and will open at the end of 2004, and it will cover on R&D works on radiation techniques for the environmental conservation and peaceful use of nuclear energy not only field of liquid samples but also field of gases and solids. The following items related to environmental conservation will be studied in Research Center for Advanced Utilization of Radiation.

Liquids

- Radiation technique for the sterilization of discharged wastewater from sewage treatment plant
- Radiation technique for the reduction of amount of activated sludge and advanced treatment of sewage
- Radiation technique for removal of algal
- Radiation technique for treatment of drinking water
- Radiation technique for treatment of non-biodegradable wastewater
- Radiation technique for treatment of non-radioactive wastewater used for decontamination of nuclear facilities

Gases

- Radiation technique for removal of dioxin in off gas
- Radiation technique for removal of toxic and smelly gas
- Radiation technique for removal of toxic gas in closed space

Solids

- Radiation technique for treatment and reuse of organic waste
- Radiation technique for restoration of contaminated soil
- Radiation technique for sterilization of hospital waste