SIX-YEAR EXPERIENCES IN THE OPERATION OF A LOW LEVEL LIQUID WASTE TREATMENT PLANT

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After the review of the techniques and experiences of other countries and considering the specific situation in Taiwan, we at the Institute of Nuclear Energy Research (INER) constructed a low-level liquid waste treatment plant in 1973 (Fig.1). Thereafter, the fuel fabrication plant, the isotope production plant and other research laboratories have been set up one by one. The amount of liquid waste has been increased from 600 tons to 2500 tons every month. The activity concentration ranges from $10^{-5}\mu Ci/ml$ to $10^{-3}\mu Ci/ml$. The waste volume and the radioactivity as well have increased gradually with the growing of the INER. The treatment plant has also been improved every year to fulfil the requirement of the INER.

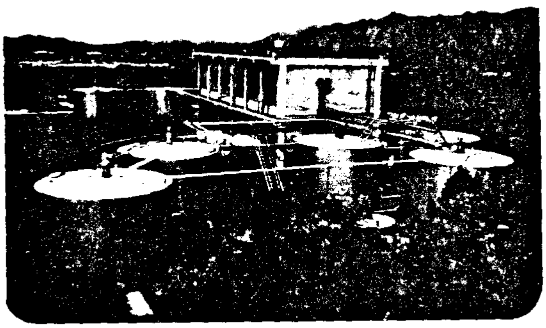

Figure 1

CONTINUOUS PROCESS

The flow digram of the low level radioactive liquid waste treatment is shown in Fig.2[1].

Receptor for liquid waste

After sampling with gross β counting and the adjustment of P^H at 6-9, the radioactive liquid waste from the operation and maintenance of the Taiwan Research Reactor and other plants was pumped to the liquid waste treatment plant. The waste is classified into two catagories. The first catagory is the liquid waste whose gross β activity is below 4×10^{-5} $\mu Ci/ml$ and is pumped to the tail end of the storage tank in the treatment plant. It is then discharged to the ground disposal area. The second catagory is that above $4 \times 10^{-5}\mu Ci/ml$ and is pumped to the head end of the storage tank for treatment.

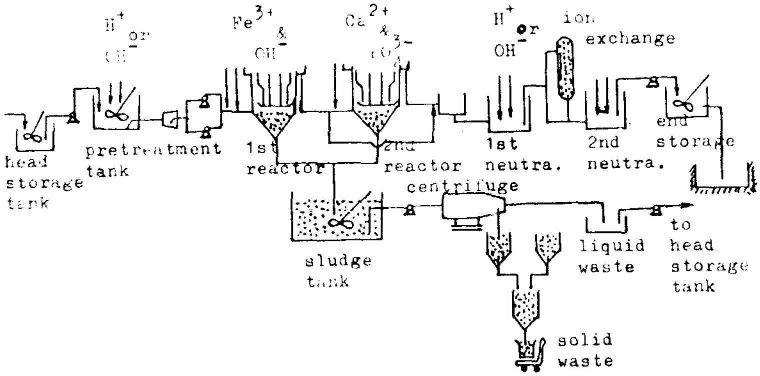

Figure 2

Liquid Waste treatment

Pump the liquid waste from the storage tank to the pretreatment tank for sampling, P^H measuremtns, radioactivity counting, and nuclide analysis. We then choose the proper chemicals and determine the quantity. After passing through the first reaction tank and the filtration tank, if the radioactivity is decreased to the discharge level, then the liquid waste will flow directly to the first and the second neutralization tanks for proper p^H adjustment, and finally it flows to the tail end of the storage tank. After sampling and counting, the liquid waste is discharged to the ground disposal area. If the liquid waste does not reach the discharge level, the clear liquid will be pumped to a second precipitation tank for precipitation with calcium phosphate. After precipitation, if the upper clear solution is below the discharge level, it will be pumped to the neutralization tank, and then to the tail end of the storage tank and finally to the ground disposal area. Otherwise it will be pumped to an ion exchange tank. If it still does not reach to the discharge level, it will be pumped to the head end of the storage for recycle.

Treatment of precipitate

Most precipitates in the two precipitation tanks are $Fe(OH)_3$, $Ca_3(PO_4)_2$, and $Ni_2Fe(CN)_6$. They will be centrifuged to a concentrate sludge which has 10-20% solid content. The sludge will be stirred with cement at the weight ratio of 2 to 1, then it will be transferred to a 53 gallon barrel for dryness and solidification. After being covered and sealed,the barrel is stored for further treatment.

Discharge of Waste liquid

Although the waste liquid in the process is monitored frequently, effluent samples should be taken and counted before discharged to the ground disposal area for the prevention of violating the regultions. The trace amount of nuclides will be absorbed or adsorped in the soil after discharged. There are 20 wells whose depths vary from 25 to 30 m around the disposal area for monitoring the contamination of underground water.

OPERATION EXPERIENCES AND IMPROVEMENT OF EQUIPMENT

The advantages and disadvantages of continuous and batch processes

The batch process uses the pretreatment tank for the addition of chemicals. The quality control (QC) group takes sample for analysis. Taking the optimum condition based on QC, the p^H of liquid waste is adjusted and the chemicals are added. The liquid waste is stirred sufficiently and settled for 6 h or overnight to precipitate the radionuclides. From the upper clear liquid, sampling is performed for counting and analysis and to determine whether it may be discharged or not.

The advantages of batch process are very short operation time and large capacity. The disadvantage is that it requires more operation tanks which are not necessary for continuous process. The continuous operation for 24 h, on the other hand, has lower capacity and requires more man power.

Improvement of ion exchange capability for vermiculite

Vermiculite, with good water permeability and high selectivity of cesium ion, is one the cheapest ion exchangers available. It is appropriate for treatment of low level radioactive liquid waste.

From the practice of the plant operation, it showes that the high concentation of ion will cause the efficiency of the vermiculite exchange capability to decrease. If the waste liquid pretreated with vermiculite before chemical treatment, then the efficiency of decontamination will be increased and the exchange capacity of vermiculite will be improved.

As the experimental data show, vermiculite has poor selectivity for ^{90}Sr-^{90}Y, and its efficiency for ion exchanges is low. The more efficient method for treatment of ^{90}Sr-^{90}Y is the precipitation with calcium phosphate.

The improvement of peat absorption for liquid waste treatment

Since the combustion capability of peat, it is not suitable to be used as a fuel. In the past years, peat was widely used in soil improvement and gardening. Recently its application shifts to the utilzation of its specific characters.

The p^H value of the solution has great influences over the absorption capability of peat. This is due to that the humic acid in peat has lower exchange or chelation reaction under high H^+ concentration. The peat has more absorption as weak alkali. Usually, the waste liquid after chemical treatment is in this range.

A 10 cm layer of peat on the ground disposal area will decrease the contamination, and make the liquid waste treatment more appropriate. After saturation, the peat should be removed for solid waste treatment. The disadventage is the small volume reduction of peat after incineration.

Improvement of sludge treatment

The sludge, the coprecipitate from liquid waste treatment plant with solid content about 3-6 W%, is centrifuged after dryness. The volume is decreased and then it is treated with cement. The solidified products are ready for final treatment. The centrifuge is a continuous horizontal type. The solid is separated from liquid by a conveyor screw. The character of the centrifuge is its ability to separate different properties of suspensions by varying the radius of rotation and the difference RPM between bowl and conveyor.

The effluent from the separation of sludge still has too high solid content. It cannot be transferred to the liquid waste storage tank. Replace the liquid storage tank with two 50 m^3 tanks as feeding and effluent recieving tanks for decanter, then the operation can meet with the requirement(2).

Environmental monitoring

The final liquid waste after treatment is discharged to the ground disposal area. The adsorption capability of soil keeps the ground water from contamination. To guard the underground water resources and prevent them from contamination, there are 20 deep wells around the disposal area for environmental monitoring. Routine sampling and analysis for several years has shown that the radioactivity is about the background. They give no evidence of contamination.

CONCLUSION

The construction and operation of this low level waste treatment plant is the first experience in Republic of China. Some improvements have been made as mentioned before.

The total volume of liquid waste treated in 6 yr was 84725 m^3. The decontamination factor was from 5 to 50. The gross beta activity discharged after treatment is 2299 mCi, less than 400 mCi per year on average which is less than the predicted discharge activity of 1 Ci per year. From the experience of operation for 6 yr, we consider batch process to be more practical than continuous process especially the capacity of treatment is concerned. The monitoring of well samples shows that the liquid waste discharged to the ground disposal area does not contaminate the environment.

REFERENCES

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