

CHAPTER 31

RADIOACTIVE WASTE WATER

CHARACTERISTICS OF THE WASTE WATER

The main sources of radioactive waste water are from nuclear reactors, isotope laboratories, nuclear research centres, from the processing of uranium ore, laundering of protective clothing used by those working with radioactive materials, and from laboratories in which radioactive substances are used for therapeutic purposes.

Water-cooled atomic reactors have two circulating water systems. Demineralized water is used in the first system for the direct cooling of radioactive material. This water transfers its heat to the second, indirect, cooling system. The cooling water in the first system is slightly contaminated with radioactivity due to corrosion of the pipes. This activity is reduced by continuous passage of part of the water through ion exchangers, so that dissociated radioactive compounds are retained in the ion exchangers while the non-dissociated radioactive components are removed continuously in suspension (Dietrich, 1958).

From this explanation it is clear that the second cooling system is protected from radioactive contamination. However, hazards may arise if the system is open, such as in the event of corrosion and damage to heat exchangers, water leakage, etc. Even so, the radioactivity in the water of the second system should be fairly insignificant.

Waste water with a very high activity is formed during the processing of nuclear fuel. Such waste water is often strongly acid.

Waste water from the processing of uranium ore is generated in the vicinity of the mines. The main sources of contamination are wash water, sand and other solid wastes. This water is dangerous as it contains isotopes with very long half-lives such as radium 226.

The waste water from research laboratories and that from laundering protective clothing differ greatly from one another, depending on the isotope employed and the method of its use.

The waste water is classified into three groups according to the level of activity.

The low activity group ranges from 10 pCi/l to 10^4 pCi/l.

The intermediate activity ranges from 10^4 pCi/l to 10^3 μ Ci/l.

The high activity ranges from 10^3 μ Ci/l to 100 mCi/l.

Treatment of the waste water

Since no method is known for influencing the radioactive properties of the components present in waste water, all methods for the decontamination of the water aim at concentrating the radioactive components. All substances thus remain physically unchanged and after treatment of the water are in the form of a concentrated residue, which can be stored under permanent control.

Due to the danger the necessary degree of deactivation of radioactive waste water must be much higher than that needed for other types of industrial waste water.

The deactivation of the radioactive waste water must be very close to 100%.

Decontamination by dilution might be used, but only if the activity of the waste water is particularly low (Ruf, 1959). In this case the radioactivity of the receiving water should not exceed the level permissible for potable water.

Radioactive waste water can be evaporated in a similar manner to other types of waste water that are difficult to deal with. This method is used mainly for the high activity group, where the quantity of water is relatively small.

Ion exchangers are used, as mentioned above, for concentrating radioactive waste water. Selective retention of the radioactive ion is often possible by suitable selection of the ion exchange material.

Ion exchange can be used for selective separation of radioactive rare earth components.

Chemical treatment of radioactive waste water is usually carried out by coagulation or precipitation. After addition of the chemicals the contents of the reaction tanks are agitated vigorously by compressed air. After settling over-night the supernatant is pumped to a storage tank. After mixing with compressed air samples are taken to check the residual activity (Swope, 1961).

If plutonium is present it is of advantage to use iron(II)sulphate or calcium hydroxide together with polyacrylamide as flocculant. If strontium 90 and/or caesium 137 are present, which is the case in strip waste resulting from reprocessing small amounts of spent uranium fuel (Kristensson et al., 1970), it is advantageous to use nickel(II)sulphate and potassium iron(II)cyanide as precipitants.

Calcium chloride, iron(III)sulphate, sodium phosphate and sodium phosphate might be used for precipitating other radioactive compounds such as ^{32}P , ^{35}S , ^{51}Cr , ^{60}Co and ^{131}I .

Strong radioactive sludge must be fixed in concrete and stored in deep holes or transported to the sea (Eliassen, 1964).

Biological methods are also used, but they are mostly suitable for very low activity waste water (Straub, 1964), and usually used after chemical precipitation.

If the waste water has a strongly inorganic character suitable suitable nutrients must be added.

Generally an activated sludge plant cannot be used for treating radioactive waste water as intensive foaming may occur during aeration.

Processing of the sludge obtained during the decontamination process gives special problems. Sludge resulting from physical-chemical treatment is dewatered on drying beds or vacuum filters (Kern, 1960).

Organic sludge from biological treatment plants will have a high level of activity as well as the sludge obtained from chemical treatment. If it contains isotopes with long half-lives, it may be especially dangerous (Wilson, 1957).

The organic sewage sludge can be treated by anaerobic digestion and dewatered. In some instances it might be burned, which leads to further concentration of activity in the ash.

The ash or dried sludge must be stored according to the level of its radioactivity.

Strontium 90 can also be removed by extraction with organic solvents. Table 31.1 gives a survey of some of the solvents which can be used.

TABLE 31.1

Solvents used for removal of strontium 90 by extraction

Keosen
 2-ethylhexyl phosphate
 Dibutyl-phosphate
 Mono(2-ethylhexyl)phosphoric acid
 2-ethyl hexanol
 Chloroform
 Di-n-octyl-amino ethanol
 Di-n-octyl-amino propanol

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