Radioactive wastes, must for the protection of mankind be stored or disposed in such a manner that isolation from the biosphere is assured until they have decayed to innocuous levels. If this is not done, the world could face severe physical problems to living species living on this planet.

Some atoms can disintegrate spontaneously. As they do, they emit ionizing radiation. Atoms having this property are called radioactive. By far the greatest number of uses for radioactivity in Canada relate not to the fission, but to the decay of radioactive materials - radioisotopes. These are unstable atoms that emit energy for a period of time that varies with the isotope. During this active period, while the atoms are 'decaying' to a stable state their energies can be used according to the kind of energy they emit.

Since the mid 1900's radioactive wastes have been stored in different manners, but since several years new ways of disposing and storing these wastes have been developed so they may no longer be harmful. A very advantageous way of storing radioactive wastes is by a process called 'vitrification'.

Vitrification is a semi-continuous process that enables the following operations to be carried out with the same equipment: evaporation of the waste solution mixed with the

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1) borosilicate: any of several salts derived from both boric acid and silicic acid and found in certain minerals such as tourmaline.

additives necesary for the production of borosilicate glass, calcination and elaboration of the glass. These operations are carried out in a metallic pot that is heated in an induction furnace. The vitrification of one load of wastes comprises of the following stages. The first step is 'Feeding'. In this step the vitrification receives a constant flow of mixture of wastes and of additives until it is 80% full of calcine. The feeding rate and heating power are adjusted so that an aqueous phase of several litres is permanently maintained at the surface of the pot. The second step is the 'Calcination and glass evaporation'. In this step when the pot is practically full of calcine, the temperature is progressively increased up to 1100 to 1500 C and then is maintained for several hours so to allow the glass to elaborate. The third step is 'Glass casting'. The glass is cast in a special container. The heating of the output of the vitrification pot causes the glass plug to melt, thus allowing the glass to flow into containers which are then transferred into the storage. Although part of the waste is transformed into a solid product there is still treatment of gaseous and liquid wastes. The gases that escape from the pot during feeding and calcination are collected and sent to ruthenium filters, condensers and scrubbing columns. The ruthenium filters consist of a bed of

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2) condensacate: product of condensation.

glass pellets coated with ferrous oxide and maintained at a temperature of 500 C. In the treatment of liquid wastes, the condensates collected contain about 15% ruthenium. This is then concentrated in an evaporator where nitric acid is destroyed by formaldehyde so as to maintain low acidity. The concentration is then neutralized and enters the vitrification pot.

Once the vitrification process is finished, the containers are stored in a storage pit. This pit has been designed so that the number of containers that may be stored is equivalent to nine years of production. Powerful ventilators provide air circulation to cool down glass.

The glass produced has the advantage of being stored as solid rather than liquid. The advantages of the solids are that they have almost complete insolubility, chemical inertias, absence of volatile products and good radiation resistance. The ruthenium that escapes is absorbed by a filter. The amount of ruthenium likely to be released into the environment is minimal.

Another method that is being used today to get rid of radioactive waste is the 'placement and self processing   radioactive wastes in

deep underground cavities'. This is the disposing of toxic wastes by incorporating them into molten silicate rock, with low permeability. By this method, liquid

wastes are injected into a deep underground cavity with mineral treatment and allowed to self-boil. The resulting

steam is processed at ground level and recycled in a closed system. When waste addition is terminated, the chimney is allowed to boil dry. The heat generated by the radioactive wastes then melts the surrounding rock, thus dissolving the wastes. When waste and water addition stop, the cavity temperature would rise to the melting point of the rock. As the molten rock mass increases in size, so does the surface area. This results in a higher rate of conductive heat loss to the surrounding rock. Concurrently the heat production rate of radioactivity diminishes because of decay. When the heat loss rate exceeds that of input, the molten rock will begin to cool and solidify. Finally the rock refreezes, trapping the radioactivity in an insoluble rock matrix deep underground. The heat surrounding the radioactivity would prevent the intrusion of ground water. After all, the steam and vapour are no longer released. The outlet hole would be sealed. To go a little deeper into this concept, the treatment of the wastes before injection is very important. To avoid breakdown of the rock that constitutes the formation, the acidity of he wastes has to be reduced. It has been established

experimentally that pH values of 6.5 to 9.5 are the best for all receiving formations. With such a pH range, breakdown of the formation

rock and dissociation of the formation water are avoided. The stability of waste containing metal cations which become hydrolysed in acid can be guaranteed only by complexing agents which form 'water-soluble complexes' with cations in the

relevant pH range. The importance of complexing in the preparation of wastes increases because raising of the waste solution pH to neutrality, or slight alkalinity results in increased sorption by the formation rock of radioisotopes present in the form of free cations. The incorporation of such cations causes a pronounced change in their distribution between the liquid and solid phases and weakens the bonds between isotopes and formation rock. Now preparation of the formation is as equally important. To reduce the possibility of chemical interaction between the waste and the formation, the waste is first flushed with acid solutions. This operation removes the principal minerals likely to become involved in exchange reactions and the soluble rock particles, thereby creating a porous zone capable of accommodating the waste. In this case the required acidity of the flushing solution is established experimentally, while the required amount of radial dispersion is determined using the formula:

$$R = \frac{Qt}{2\,mn}$$

R is the waste dispersion radius (metres)
Q is the flow rate (m/day)
t is the solution pumping time (days)
m is the effective thickness of the formation (metres)
n is the effective porosity of the formation (%)

In this concept, the storage and processing are minimized. There is no surface storage of wastes required. The permanent binding of radioactive wastes in rock matrix gives assurance of its permanent elimination in the environment.

This is a method of disposal safe from the effects of earthquakes, floods or sabotages.

With the development of new ion exchangers and the advances made in ion technology, the field of application of these materials in waste treatment continues to grow. Decontamination factors achieved in ion exchange treatment of waste solutions vary with the type and composition of the waste stream, the radionuclides in the solution and the type of exchanger.

Waste solution to be processed by ion exchange should have a low suspended solids concentration, less than 4ppm, since this material will interfere with the process by coating the exchanger surface. Generally the waste solutions should contain less than 2500mg/l total solids. Most of the dissolved solids would be ionized and

would compete with the radionuclides for the exchange sites. In the event where the waste can meet these specifications, two principal techniques are used: batch operation and column operation.

The batch operation consists of placing a given quantity of waste solution and a predetermined amount of exchanger in a vessel, mixing them well and permitting them to stay in contact until equilibrium is reached. The solution is then filtered. The extent of the exchange is limited by the selectivity of the resin. Therefore, unless the selectivity for the radioactive ion is very favourable, the efficiency of removal will be low.

Column application is essentially a large number of batch operations in series. Column operations become more practical. In many waste solutions, the radioactive ions are cations and a single column or series of columns of cation exchanger will provide decontamination. High capacity organic resins are often used because of their good flow rate and rapid rate of exchange.

Monobed or mixed bed columns contain cation and anion exchangers in the same vessel. Synthetic organic resins, of the strong acid and strong base type are usually used. During operation of mixed bed columns, cation and anion exchangers are mixed to ensure that the acis formed after contact with the H-form cation resins immediately neutralized by the OH-form anion resin. The monobed or mixed bed

systems are normally more economical to process waste solutions.

Against background of growing concern over the exposure of the population or any portion of it to any level of radiation, however small, the methods which have been successfully used in the past to dispose of radioactive wastes must be reexamined. There are two commonly used methods, the storage of highly active liquid wastes and the disposal of low activity liquid wastes to a natural environment: sea, river or ground. In the case of the storage of highly active wastes, no absolute guarantee can ever be given. This is because of a possible vessel deterioration or catastrophe which would cause a release of radioactivity. The only alternative to dilution

and dispersion is that of concentration and storage. This is implied for the low activity wastes disposed into the environment. The alternative may be to evaporate off the bulk of the waste to obtain a small concentrated volume. The aim is to develop more efficient types of evaporators. At the same time the decontamination factors obtained in evaporation must be high to ensure that the activity of the condensate is negligible, though there remains the problem of accidental dispersion. Much effort is current in many countries on the establishment of the ultimate disposal methods. These are defined to those who fix the fission product activity in a non-leakable solid state, so that the general dispersion can never occur. The most promising

outlines in the near future are; 'the absorbtion of montmorillonite clay' which is comprised of natural clays that have a good capacity for chemical exchange of cations and can store radioactive wastes, 'fused salt calcination' which will neutralize the wastes and 'high temperature processing'. Even though man has made many breakthroughs in the processing, storage and disintegration of radioactive wastes, there is still much work ahead to render the wastes absolutely harmless.