Technology Information	
Area	3
Title	Removal of radioactive materials from the seawater in the harbor
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1. Overview of Technologies (features, specification, functions, owners, etc.)

Introduction

We are a French company specializing in the treatment of liquid nuclear waste, oil, grease, effluents, sludge and oily sludge etc. We are pleased to propose our technology as a solution to help purify water contaminated with radioactive elements and/or radionuclides by completely decontaminating the waste using a biological process, a technology in which we have lots of experience.

We hold patents of two processes, the first issued in 1995, Patent No. 15-01581, entitled: "*Method and device for processing oils and solvents contaminated by radioactive substances*." This patent was designed to capture 10 radionuclides of low and very low activity by ion exchange: (10 000 Bq / liter) (LLW and VLLW) such as: ^{60}Co, ^{58}Co, ^{64}Mn, ^{110}Ag, ^{65}Zn, ^{54}Sb4, ^{134}Cs, ^{137}Cs, Cs, Niobium and Tritium.

Over several years we simplified and improved the process using specific strains of microbes identified to provide complete transformation of the waste to constituents that can be dealt with efficiently using conventional means. The select microorganisms allow us to extract all metals from the matrix and all liquids microbiologically.

By attempting to accelerate the process known as bioleaching, and to develop an alternative, more efficient method of treatment and not involving the same types of microorganisms, we have found heterotrophic bacteria that are much more rapid than the biochemical reactions of autotrophic bacteria. These microorganisms synthesize several molecules capable of engaging in specific relations with metals by ionic exchange. We can use them to remove radioactive isotopes such as Tritium, ^{14}Carbon, ^{35}Sulphur and ^{32}Phosphorus.

This new process was patented in 2012 by INPI (National Intellectual Property Institute) under Patent No. 10 56596 entitled "*Method and Apparatus for Treating Oils, Greases, Solvents, Water or Oily Sludge Contaminated by Radionuclides*." Indeed, the bacteria used are able to extract all the radioactive or non-radioactive heavy metals from their matrix or liquid in which they are

located and thus purify liquids and, in this specific case, the salt (or non-salt) water.

During the process of extraction and separation of liquid or sludge, we can separate and release metals and radionuclides or extracts in an extremely reduced volume into the appropriate containers, in compliance with the DER, as defined by the client's engineers. The process is commonly used in France in steel mills to extract the heavy metals found in the dregs before they are write-offs.

Our new process (second patent) has allowed us to treat cutting oils contaminated with radionuclides such as Ag, Al, As, Cd, Co, Cr, Cu, Cs, Fe, Fe, Hg, Ni, Pb, Sb, Si, Mg , Ti, U, Zn, Zr, Mn, Sr, etc. We know that we can extract and capture all the metal elements on the Mendeleev periodic table, including those that are non-radioactive.

With the two patented processes, we can treat effluents, water, oil and other contaminated products with an activity of 6700 $Bq.g^{-1}$ or 6.7 million Bq per kg in equivalent ^{60}Co.

Removal of radioactive materials from the water in the harbor (Current situation)

The rate of tritium contamination in the samples provided are 1400, 520, 270, 210 Bq / l, which is not very high. We presume there must also be Cesium based on the fact that facing the Fukushima site approximately ten kilometers offshore large bass have been found to be contaminated with Cesium.

The treatment method proposed

Decontamination of sea water can be accomplished using our technology by pumping water from the tank in the zone that is most contaminated at a rate of 333 m^3/d or higher, depending on preliminary tests, and possibly up to 800m^3/d. This can be done due to the low activity indicated by the different samples analyzed that show the rate of contamination is not very high. The effluent that contains sea water can be treated as other types of effluents (provided that there is no oil in the water) by passing it through the tank used as a reactor into which a suitable microbial mixture is injected.

2. Notes

Technology Readiness Level

When the first patent (No. 15 01581) was issued in 1995, the process was researched and

developed at a nuclear plant in France treating LLW of cutting oil with contamination rate of 10 000 Bq/liter, contaminated by ten radionuclides that were a side-product from the periodic mechanical maintenance of the primary circuit reactor. We were prepared to build a processing machine.

Since 1996 we have had numerous contracts using our biological process to treat oils and effluents in France. Some select samples:

- Processing 25,000 liters of oil transformed into water with a residual waste of 3 per 1000. The machine had a processing capacity of 200 liters/day;
- Biological treatment of 4 m^3 of oil contaminated with plutonium from swing bridge mechanisms and fission regulator mechanisms;
- Treatment using our biological process of effluent polluted by hydrocarbon;
- Biological treatment of sludge from spent fuel withholding tanks;
- Degradation of 25,000 liters of cutting oil contaminated with natural uranium;
- Depollution, by means of biological process, of effluents that are composed of waste water and various soluble oils, side-products from washing the tanks that manufacture these oils.

Timeline For Application

The technology has gone through numerous tests and prototypes and is ready for industrial use.

Cost

Our process costs significantly lower than any of the other existing technologies. However, to be in a position to provide an accurate cost associated with using this process to treat the contaminated waste, more information is required regarding, among other factors, the concentration of Tritium (and possibly ^{137}Cesium and ^{90}Strontium) in grams/liter in the waste water stored in the big reservoirs.

Challenges

This unique and environmentally friendly technology using micro-organisms to treat radioactive liquid waste is a viable choice that brings the client substantial cost savings and yields a significantly lower volume of final waste while using a clean tech solution.

In the nuclear industry, all treatment of waste by biological means is trying by any account.

The key challenge for us is convincing waste management decision makers and users to accept and adapt to the idea of a new and innovative technology as being a safe and feasible alternative.

We feel very confident that our technology addresses extremely important problems related to radioactive liquid waste treatment in general and frequently difficult-to-treat waste in particular. This process is not only a good solution from a technological standpoint and its versatility for multiple applications but it is also a considerable capital investment for the user. We would be very happy to provide further information upon request.