Distillation: Waste Water Treatment for Release to Sewers - 11067

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ABSTRACT

Eckert & Ziegler Isotope Products has produced reference/calibration, medical, and industrial radioactive sources since 1967. Curie levels of radioactive materials, including Ba-133, Cd-109, Co-57, Cs-137, Gd-153, and Ge-68, are handled daily in the laboratories. During the chemical processing of radionuclides, strong acid, strong base, and high levels of radioactive nuclide residuals are introduced into the waste water. As a result, due to its high chemical and radiological content, that waste water must be treated before discharge. Distillation has been chosen to do this. The one-gallon distiller used for this process is available at most hardware stores, making it very cost effective, given the results. This paper discusses the effectiveness and efficiency of distillation for waste-water treatment. The pre- and post-treated waste-water test comparison showed a 90 percent radiological and chemical load reduction.

INTRODUCTION

For 40 years, Eckert and Ziegler Isotope Products (EZIP) has produced various types of reference/calibration, medical, and industrial sources, using more than 80 different nuclides. The major nuclides among those are Ba-133, Cd-109, Co-57, Cs-137, Gd-157, and Ge-68. Radionuclide-batch preparation and source production both produce waste water with multiple chemicals and metals, generating about 50 gallons of contaminated waste water per month. Local authorities, such as cities, usually control and regulate the chemical and metal content of waste water and require a license to discharge such water to the sewer. Additionally, the US NRC (United States Nuclear Regulatory Commission), and many agreement states regulate isotopes based on 10 CFR (Code of Federal Regulations) 20 Appendix B [1]. EZIP's waste water can be disposed of only after reducing its chemical, metal, and isotopic content.

To accomplish this, EZIP initially used a filtration system with multiple particulate filters and a charcoal filter. This was a very inefficient method for achieving regulatory compliance vis-à-vis Total Dissolved Solids (TDS) and chlorides. The lead content in the waste water from shielding material was also a major issue for the local authorities. Subsequently, a distillation system was tried, with good results: It regularly removes more than 90% of the regulated chemical and metal content and isotopes, and resulting water can be discharged into the sewer without problems. Figure 1 describes this process of waste-water treatment for sewer discharge.

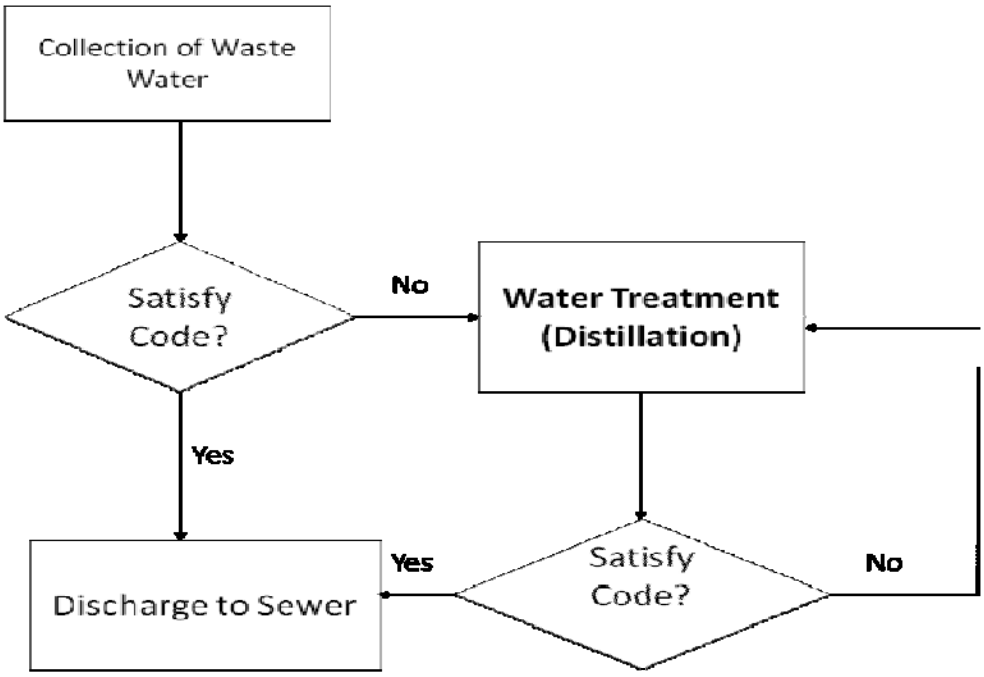

Fig. 1. Distillation process for sewer discharge

DISTILLER

A simple distiller was chosen for the process, in part because of its low cost and ready availability at some hardware stores and on line. An electrical unit, it requires only plugging into a 115-volt receptacle. A distiller typically processes a gallon of waste water every four hours, yielding two gallons of treated water per 8 hour shift. Figure 2 details the distiller components.

PRE-TREATED WASTE WATER

To test for all the regulated contaminants, between October, 2009, and January, 2010, 30 gallons of waste water were collected from the radiochemistry lab that prepares the nuclide batches for the production groups. This lab's waste water was chosen because it presented the greatest challenge. As a result of the group's radionuclide-batch preparation, which uses multiple chemicals, their waste water has the highest radioactive and chemical content.

DISTILLATION PROCESS

All waste water is collected in an under-sink sump tank. When the sump filled, the water is transferred to a processing lab, to measure and adjust the water's pH by adding calcium

Distiller Exterior **Distiller Interior**

Distillers in Operation

Fig. 2. Waste-water treatment distiller

carbonate ($CaCO_3$) because distillation has only a small effect on pH. The water then is put through a filtering system to remove large dirt and other particulates. Finally, that water is transferred into a distiller. In about four hours. A very small amount of highly-concentrated residue remains in the bottom of the distiller, which is easily cleaned and dried with paper towels, which then are disposed of as solid waste.

WATER TESTS

Two types of testing were performed on the waste water, one for radioactivity, and the other for chemicals. For the radioactivity tests, the entire 30 gallons of a waste water batch were well mixed and one liter was drawn into a Marinelli beaker for analysis with an HPGe [High Purity Germanium] detector. The results were recorded and the liter was transferred to the distiller. This procedure was repeated until the whole 30 gallons were distilled once. The test then was repeated. A liter was transferred to a Marinelli beaker and counted under the same conditions, and the results, recorded.

TestAmerica [2] performed the chemical testing. Table I shows the test parameters and analytical methods. The City of Burbank, where the laboratory is located, requires these chemical tests prior to authorizing waste-water discharges to the sewer. The water, pre- and post-treatment, was collected in the same manner as that for the radiological testing.

Table I. Summary of Chemical Tests

Test Parameter	Regulatory Limit	Analytical Method [a]
pH	5.5-9.5	[3]
Chloride	275 mg/L	[3]
Total Dissolved Solid (TDS)	1,200 mg/L	[3]
Oil and Grease	300 mg/L	[4]
Total Suspended Solid	104 mg/L	[3]
Phenol	1.5 mg/L	[3]
Sulfate	420 mg/L	[3]
Cyanide	650 µg/L	[3]
Metals	Various [b]	[5]

a see references
b The local authority controls Cr, Cu, Ni, Pb, and Zn; for example, their lead limit is 430 µg/L.

TEST RESULTS FOR PRE- AND POST-TREATED WASTE WATER

Table II compares the pre- and post-test results, which show distillation is very effective in reducing both the radioactivity and the chemical "contaminants." It removed more than 90 % of the major nuclides in the water, dropping the concentration to the releasable level mandated by 10 CFR 20 Appendix B. While the distiller removed most radioactivity and chemicals, pH improved only slightly when the waste water was acidic, hence the preliminary pH adjustment noted above. No regulatory agency has had a major issue since distillation has been used. The City authority has been collecting the water sample from the whole batch of treated waste water and all sample results have been within all regulatory limits. The distillation of EZIP's waste water has annually made several hundred gallons releasable without trouble and with only a small time investment. Environmentally friendly, the process has been very cost effective as well.

Table II. Comparison of Results and Regulatory Limits

Test Parameter	Pre-Treatment	Post-Treatment	Reduction Ratio (%)
pH	2.4	2.9	[a]
Chloride	1,640 mg/L	19.7 mg/L	98.8%
Oil and Grease	2.3 mg/L	[n/d] [b]	>99%
Phenol	36.0 mg/L	[n/d]	>99%
Sulfate	31.7 mg/L	0.890 mg/L	97.2%
Cyanide	11.3 µg/L	5.90 µg/L	47.8%
Total Dissolved Solids (TDS)	3,940 mg/L	26.0 mg/L	>99%
Total Suspended Solids (TSS)	213 mg/L	[n/d]	>99%
Chromium	349 µg/L	276 µg/L	20.9%
Copper	25.0 µg/L	16.6 µg/L	33.6%
Lead	6,030 µg/L	7.50 µg/L	>99%
Nickel	412 µg/L	144 µg/L	65.0%
Zinc	2,610 µg/L	14.2 µg/L	>99%
Co-57	5.07 µCi/L	0.00552 µCi/L	>99%
Co-60	0.0126 µCi/L	[n/d]	>99%
Ge-68	0.0154 µCi/L	[n/d]	>99%
Cd-109	1.13 µCi/L	[n/d]	>99%
Cs-137	0.147 µCi/L	[n/d]	>99%
Eu-152	0.0211 µCi/L	[n/d]	>99%
Gd-153	8.40 µCi/L	0.00895 µCi/L	>99%

a pH is increased 20%.
b Not detected

REFERENCES

1. "Standard for Protection Against Radiation," Title 10 Code of Federal Regulations Part 20 Appendix B, Table 3 (May 21, 1991).

2. TestAmerica Laboratories, Inc. (environmental testing), St. Louis MO.

3. "Method for Chemical Analysis of Water and Waste," EPA [Environmental Protection Agency] 600/4-79-020 (March, 1983, and subsequent revisions).

4. "Method for Organic Chemical Analysis of Municipal and Industrial Wastewater," 40 CFR Part 136, Appendix A (October 26, 1984, and subsequent revisions).

5. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Test Methods Index (3rd edition) (November, 1986).