Radioactive Water Treatment at a United States Environmental Protection Agency Superfund Site - 12322

John C Beckman, US Army Corps of Engineers, Baltimore District, Baltimore, MD 21201

ABSTRACT

A water treatment system at a United States Environmental Protection Agency (USEPA) Superfund site impacted by radiological contaminants is used to treat water entering the site. The United States Army Corps of Engineers (USACE) is actively managing the remedial action for the USEPA using contracts to support the multiple activities on site. The site is where former gas mantle production facilities operated around the turn of the century. The manufacturing facilities used thorium ores to develop the mantles and disposed of off-specification mantles and ore residuals in the surrounding areas.

During Site remedial actions, both groundwater and surface water comes into contact with contaminated soils and must be collected and treated at an on-site treatment facility. The radionuclides thorium and radium with associated progeny are the main concern for treatment. Suspended solids, volatile organic compounds, and select metals are also monitored during water treatment.

The water treatment process begins were water is pumped to a collection tank where debris and grit settle out. Stored water is pumped to a coagulant tank containing poly-aluminum chloride to collect dissolved solids. The water passes into a reaction tube where aspirated air is added or reagent added to remove Volatile Organic Compounds (VOC'S) by mass transfer and convert dissolved iron to a solid. The water enters the flocculent polymer tank to drop solids out. The flocculated water overflows to a fluidized bed contact chamber to increase precipitation. Flocculation is where colloids of material drop out of suspension and settle. The settled solids are periodically removed and disposed of as radioactive waste. The water is passed through filters and an ion exchange process to extract the radionuclides. Several million liters of water are processed each year from two water treatment plants servicing different areas of the remediation site. Ion exchange resin and filter material are periodically replaced and disposed of as radioactive waste. A total of 0.85 m3 of waste sludge per year requires disposal on average, in addition to another 6.6 m3 of waste cartridge filters.

All water discharges are regulated by a state of New Jersey Pollutant Discharge Elimination System Permit implemented by the Federal Water Pollution Control Act (Clean Water Act). Laboratory analyses are required to satisfy requirements of the state NPDES permit. Specific monitoring parameters and discharge rates will be provided.

INTRODUCTION

A water treatment system at a United States Environmental Protection Agency (EPA) Superfund site containing radioactive material is used to treat water entering the site. The United States Army Corps of Engineers (USACE) manages the remediation of the site by contracting work for hydraulic structures, soil and building debris excavation and disposal, to contain and remediate impacted areas. The area is an industrial and residential setting where formerly, gas mantles for lamps were manufactured and the associated thorium ores and mantle material was disposed.

Both groundwater and surface water that comes into contact with contaminated soils when removed from excavations will be treated at an on-site treatment facility. The radionuclides thorium and radium with associated progeny are the main concern for treatment. Other metals and select organic contaminants are also monitored during water treatment. The water treatment process and regulatory controls will be explained.

EPA Clean Water Act: the basis to the Clean Water Act (CWA) was the Federal Water Pollution Control Act of 1948 but the Act was significantly expanded and reorganized in 1972 with later amendments in 1977. The Act regulates quality standards for surface waters and part of that Act is implementing pollution control programs for wastewater standards and water quality standards for contaminants in surface waters.

CWA made it unlawful to discharge any pollutant from a point source into navigable waters unless a permit was obtained. The National Pollutant Discharge Elimination System (NPDES) permit program regulates discharges. Homes and industrial facilities can discharge to the municipal system, but there are local ordinances on pollutants and volumes. The NPDES permit specifies pollutant parameters and limitations for monitoring discharges. Monthly reporting includes discharge flows and a monthly average flow. Treatment plant operators must take specialized training and meet certification requirements for the respective state.

Operation of the site treatment plant follows an Operations and Maintenance Manual with guidance provided by the NPDES Permit.

METHOD

Two treatment plants operate at the site, both processes are the same (Figure 1). Operations of the plants are similar to industrial wastewater treatment rather than municipal sewage treatment.

1. Site 1. Raw water is pumped from permanent sumps or trucked to a 605,600 liter modular storage tank (Figure 2). Normal water quality parameters are monitored monthly with the addition of radionuclides monitored as in Table 1. Gross Alpha/beta radionuclides are monitored weekly.
2. Water at Site 2 is stored in a 378,500 liter prefabricated and lined pool (Figure 3). Monitoring is weekly for flows, ph and radioactive parameters. Different organics are monitored than at Site 1. Debris and grit settle out. Stored water is pumped to a coagulant tank where poly-aluminum chloride, ferric sulfate or alum is added to collect dissolved solids.
3. The water passes into a reaction tube where aspirated air is added or reagent added to remove Volatile Organic Compounds (VOC'S) by mass transfer and convert dissolved iron to a solid.
4. The water enters the flocculent polymer tank where flocculating agent is added to drop solids out (Figure 4). The flocculated water overflows to a fluidized bed contact chamber to increase precipitation. Flocculation is where colloids of material come out of suspension in the form of floc or flakes. Chemical clarification agents added during flocculation remove iron. Tests on the flocculated water are conducted to establish the optimum coagulant polymer type and dosage. The fine particles in the water remain continuously in motion due to electrostatic charge repelling each other. The clarification agent neutralizes the charges in order for the particles to be removed.

5. The water overflows to an inclined plate clarifier where clarification media may be added. The clarified water passes thru to the multi-stage filter trailer. The sludge from the clarifier or settled solids in the flocculation tank are removed and disposed of with the radioactive waste.
6. The filter trailer consists of sand filter (Figure 5); to remove the last suspended solids and activated carbon to remove organic compounds.
7. The water then passes through two sets of ion exchange resins absorbing radium and thorium by creating an insoluble radium-barium complex. A proprietary resin compound is used.
8. Water passes thru a final bag filter prior to discharge. Treated water discharge at Site 2 is 378.5 liters/minute (100 gallons/min) and at Site 1 is 189 lpm (50 gpm).

Figure 1: Water Treatment Flow Diagram

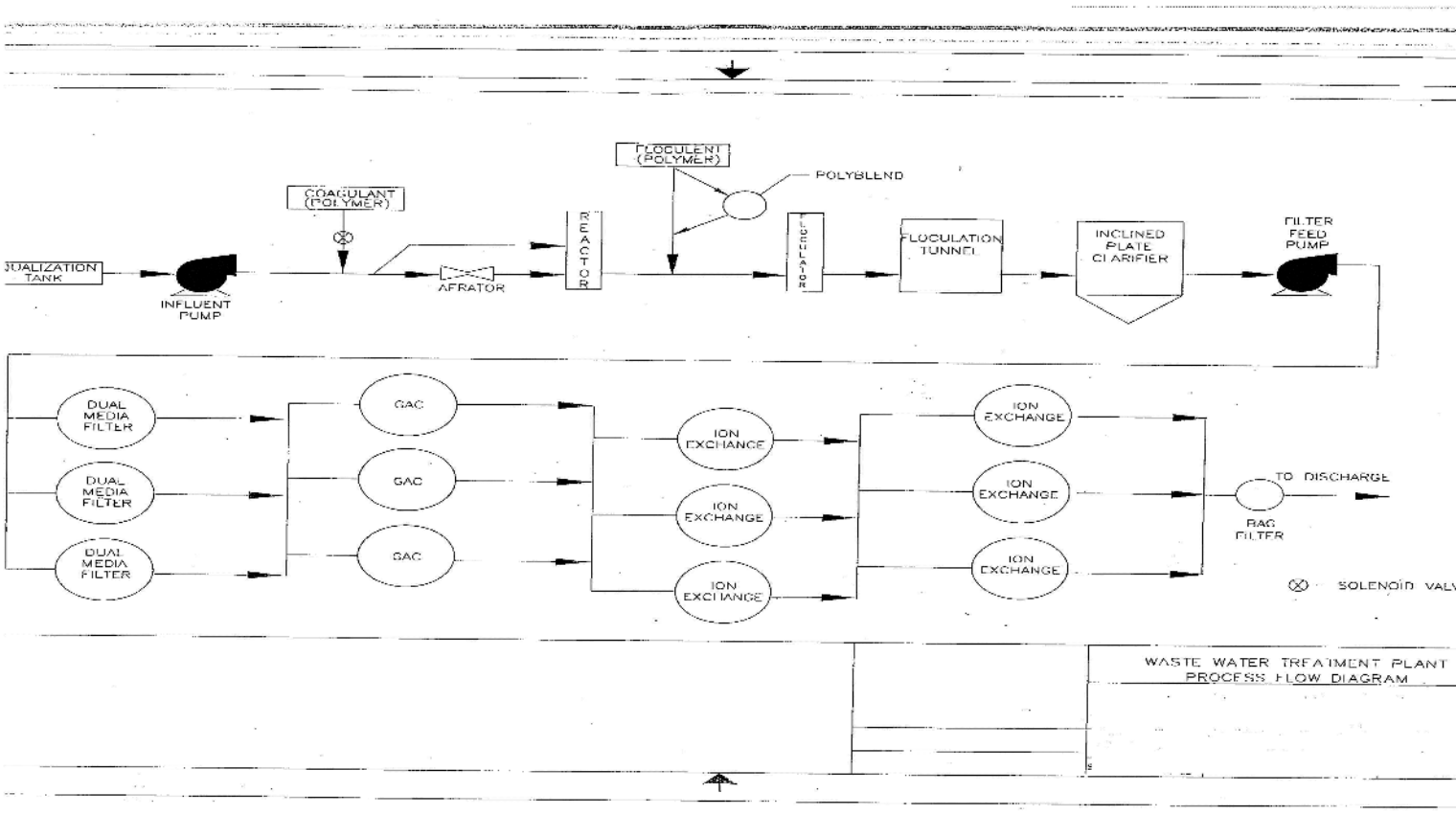

Figure 2: Water Treatment System Showing Modular Tank

Figure 3: Water Treatment System Showing Prefabricated Pool

Figure 4: Flocculation Tank

Figure 5: Filter Trailer

RESULTS

The Discharge Monitoring Report for site 1, (Table I) shows the parameters monitored. There have been no exceedances throughout the operational history. The storage reservoirs allow for maintenance during low flows and allow for particle settlement before water flows through the system. Radium and daughters are in equilibrium with thorium, therefore thorium is indirectly monitored. Flows can vary from a few thousand liters per day to millions of liters in large rain events.

Table I: Discharge Monitoring Report, Site 1

Parameter		Permit Limitation	Results	# of samples	Exceedance (Yes/No)
pH(S.U.)	Minimum	6	7.2	1	No
	Maximum	9	7.6	1	No
	Average	N/A	7.3	4	No
Chronic Toxicity	Minimum	33%	>100%	1	No
	Maximum	N/A	>100%	1	No
	Average	N/A	>100%	1	No
Gross Alpha	Minimum	N/A	4	1	No
	Maximum	15	5	1	No
	Average	MR	5	4	No
Gross Beta	Minimum	N/A	14	1	No
	Maximum	30	20	1	No
	Average	MR	17	4	No
Radium 226 + Radium 228 (pCi/L)	Minimum	N/A	1	1	No
	Maximum	5	2	1	No
	Average	MR	1	4	No
Total Uranium (ug/L)	Minimum	N/A	1	1	No
	Maximum	30	2	1	No
	Average	MR	1	4	No
Discharge Flow (gallons/day)	Maximum	MR	105,656	1	No
Monthly Average Flow (gallons/day)	Average	MR	40,786	19	No

S.U. Standard Units

"N/A" denotes not applicable

Toxicity Testing only required quarterly

System Limitations: Monthly maximum discharges: The monthly maximum discharge flow of 37,000 liters/day to several hundred thousand liters/day. Site 2 flow is 153,000 liters/day monthly average. Average flows at site 1 are zero to 4.1 million liters/month. Site 2 flows are 410,000 to 2 million liters/month. Processing limits at site 1 are 189liters/minute (lpm) and at Site 2, 378 lpm.

Rain/ snow events: The potential water capacity is high during rain/snow events, must be stored, and is kept at less than half capacity most the time.

Metals parameters are shown in Table II: Coagulants are added in-line prior to flocculator tank to flocculate and settle incoming solids, precipitate heavy metals, iron and manganese. The system handles most pollutants, iron and manganese slows the process. This is why chemicals are added to the flocculation tank. Sewage spills, a rare occurrence, must be chlorinated. There was one incidence that occurred during the excavation of a combined storm water/sewage line and a small amount of sewage required treatment prior to entering the water treatment plant.

Table II: Discharge Monitoring Report, Site 2

Parameter		Permit Limitation	Results	# of samples	Test Reporting Limit ug/L	Exceedance (Yes/No)
Zinc (Total Recoverable ug/L) RQL= 10 ug/L	Minimum	N/A	11	1	5 N/A	No
	Maximum	200	11	1		No
	Average	100	11	1		No
Copper (Total Recoverable ug/L RQL = 2 ug/L	Minimum	N/A	4	1	2 N/A	No
	Maximum	100	4	1		No
	Average	50	4	1		No
Lead (Total Recoverable ug/L RQL = 1 ug/L	Minimum	N/A	1	1	1 N/A	No
	Maximum	100	1	1		No
	Average	50	1	1		No
Heptachlor Ug/L RQL = 0.02 ug/L	Minimum	N/A	0.02	1	0.02 N/A	No
	Maximum	0.02	0.02	1		No
	Average	MR	0.02	1		No
MR denotes monitor and report only						
"N/A" denotes not applicable						

Filter backwashing: When line pressure across the filters exceeds 5 psi, backwash filters and backwash water is discharged to head of plant for re-processing. Filter replacement is on an infrequent basis.

Feed Lines: Site 2 has water pumped through lines to the plant. Lines are leak tested and double walled pipes are used to guard against water line breakages.

Site 1 plant processed 26.5 million liters/yr. Site 2 plant processed 34 million liters/yr

Radionuclide Treatment: Ion exchange filters remove Radium, Thorium and daughters. Ion exchange media requires a full change every three years and partial media replacement less frequent depending on water and contaminant volumes. Sometimes portable tanks are placed to store and settle the water prior to water lines constructed. The portable tanks are then emptied and de-contaminated.

Activated carbon also removes radioactive gases dissolved in water. Filters are collected for radioactive disposal not mixed waste.

Each system is inside radioactive materials controlled area. Entry requires a local radiation work permit, controlled area access and PPE procedures. All items brought out of the area must be surveyed for contamination.

Effluent is sampled at the final discharge point of the plant. Limits are, gross alpha 15 pCi/L, gross beta 50 pCi/L, Radium 226/228 5 pCi/L , Total Uranium 30 ug/L.

Site 2 generates6.6 cubic meters of cartridge filters over 4 yrs. Site 1 generated an average of 0.2 ft3. About 14 m3/yr of sediment were generated for disposal at both plants.

Water Controls:

Discharge Monitoring Reports are issued each month and an annual summary published.

Contractor will control storm water to prevent the clean water flow into excavations and minimize the quantity of impacted water. Temporary sumps are installed at each excavation until the excavation is complete. Portable storage tanks are sometimes used to store and allow sediment to settle in the tanks prior to trucking to the water treatment plant. Direct water pumping is also used to transfer excavation site water.

Excavation waste is stored and collected prior to disposal. If not immediately containerized, excavated material is managed for water runoff and infiltration.

DISCUSSION

Use of the water treatment systems drastically reduces the amount of contaminated water requiring solidification and water disposal to near zero. Millions of liters of potentially contaminated water from excavation activities is treated and released within permit limits. A small volume of solid radioactive waste (21 cubic meters) is generated annually from water treatment process operations. Management of ground and surface water is effectively controlled in remediation areas by the use of sumps, erosion control measures and pumping of water to storage vessels. Continued excavations can be made as water impacting the site is effectively controlled.

REFERENCES

Clean Water Act, United States Environmental Protection Agency, 1972

NPDES Permit, Surface Water Discharge Equivalent Modification, New Jersey, 2006

Waste Water Treatment and Operations Maintenance Plan, Sevenson Environmental Services, Inc., 2005