Solar Pond Seepage Evaluation and Prevention Methods

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Seepage is a common problem plaguing most solar salt operations. In a new venture, the design engineer is always faced with choosing adequate land suitable for pond operation. In an established system, it is often desired to evaluate pond seepage. This paper suggests ways to determine leakage rates and tests to evaluate soils. Techniques are also outlined showing some proven methods to reduce leakage. A simple field test is shown how to determine if new land is an acceptable candidate against leakage without need of synthetic liners.

1. SOLAR POND BASIC STREAMS.

All solar brine movement can be broken down into 8 streams. They are: 1. Input to the pond; 2. Evaporation; 3. Flow out of the pond; 4. Ending brine in the pond; 5. Entrained brine; 6. Salt deposit; 7. Leakage; and 8. Brine in the pond at the start. Depending on the event, some of these streams my be zero. This report will mainly deal with stream number 7. Leakage.

Even small leakage steals valuable brine from solar ponds especially in areas of low evaporation, and where brine must be concentrated over long periods. For example, the most complex solar pond operation in the world is IMC Kalium's Ogden, Utah operation (Formally Great Salt Lake Minerals Corp, GSL). Brine at the Ogden complex is subjected to the sun for two years as it journeys through 100 ponds. In such a complex, a 30 centimeter deep pond who's surface level drops only 0.25 millimeter per day leakage, results in a 62 percent loss of volume over the two year period.

Many solar salt complexes have failed because ponds were built over poor soils with high leakage. This report outlines some testing procedures.

2. LEAKAGE TEST IN EXISTING PONDS.

2.1 Water method

The very best and most sensitive test for leakage needs large quantities of sweet water. This can be supplied with rain, or by pumping water into the pond being tested. The procedure is itemized below.

1. Enough rain or water must be available to run the test for a week or more. If an inch of evaporation is expected for the week, an inch of water will need to be added. The longer the test, the greater the accuracy.
2. Choose a solar pond with at least 15 cm of brine depth.
3. Stop all flow in and out of the pond. The pond may not receive or discharge brine during the test.
4. Take accurate measurements of the pond level. This should be done each day starting a week before rain or when water is added and three to four days after the brine returns to it's density or concentration state before the water was added.
5. Along with the level measurements, the brine density must also be measured. Density is an extremely accurate method. Hydrometers can be purchased with sensitivities measuring 1 part per 1000. Also, a good tracer should be

analyzed (such as magnesium) but not mandatory for the test.

6. Plot the depth and concentration data each day on the same chart.

Of course, rain cannot be ordered at will, but knowledge of the weather in the area will help in planning the test. It may not be possible to obtain a source of water either by rain or pumping. If not, the Material Balance method is the next best method explained in the section 2.2.

The basis of the water test is that a pond with no leakage having concentration, b, at level, w, and then diluted with water, will return to the same level and same concentration when subjected to evaporation. The pond is measured each day and when the concentration comes back to, w, the level is compared its original level, b. If the level is "d" the amount of brine leaked out is almost exactly the difference between b and d. The leakage rate is the difference divided by the time of the test.

Level measurements can be made within a millimeter by measuring the pond level from the top of a stake or other stationary reference point. This is usually done at each corner of a pond and then averaged. When a pond is not ruffled by the wind, the recorded data should be shown with an asterisk to signal it was taken during a calm period.

It is possible that level measurements are difficult to take in regions of constant wind, but this can usually be overcome by graphing the data and drawing a smooth curve. For example, Figure 1 shows the pond level at point B when it rains. The specific gravity is at point W. The pond is diluted with the rain and the level goes to point C and the specific gravity goes to X. As the water evaporates, the specific gravity increases to point Y which is the same concentration as it was just before the rain, at W. If there were no leakage, the level of the pond would return to the same level at point B. But, in the example, it returns to point D, 30 millimeters lower than point B. This is caused by leakage and the rate of leakage and evaporation are easily calculated. If a tracer is also followed such as Magnesium, it should support the specific gravity data.

2.2 Material balance method.

Material balancing is also an accurate method to evaluate leakage in a pre-concentration pond or a halite (salt) pond, a static pond is needed to run the test. In theory, a pond having flow in and out could also be used but finding metering devices with the necessary accuracy would be very expensive if they could be found at all. These are the steps.

1. Choose a solar pond at least a hector in size, or make one of that size over the area to be tested.
2. The brine depth in the pond should be 15 to 30 centimeters deep.
3. Measure the beginning volume of brine in the pond. This is done by placing markers along the dikes to form an imaginary grid over the pond

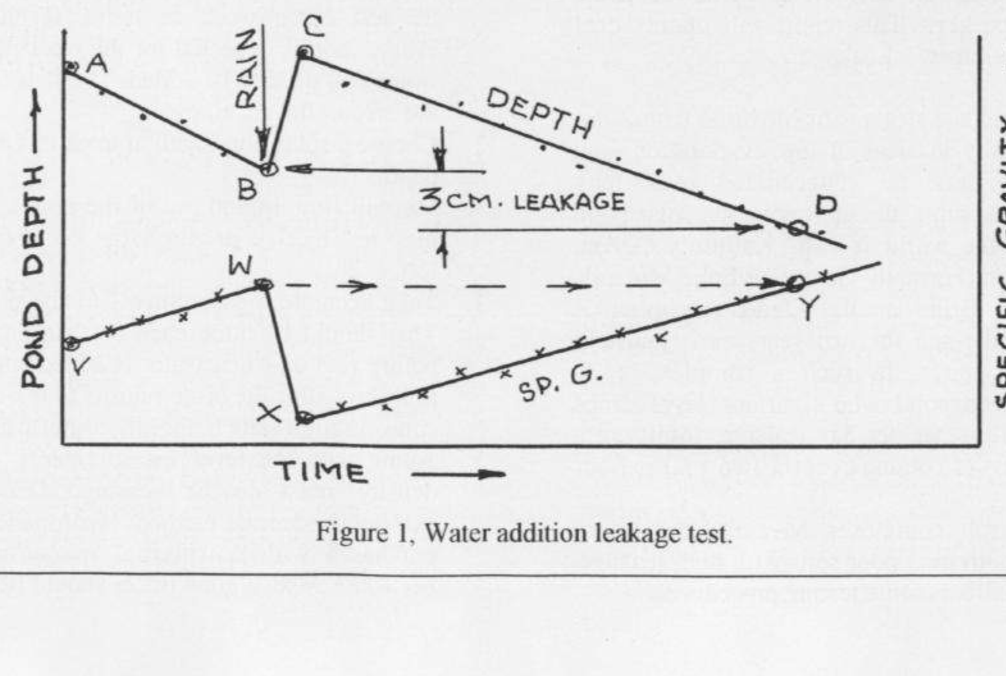

Figure 1, Water addition leakage test.

surface. The depth is measured at these grid intersections. This is done at the beginning of the test, each week after, and at end of the test. If the test lasts four weeks, there will be 5 brine volume measurements taken.

4. The concentration of the pond must also be accurately measured. Measure a component that remains soluble over the entire test. Magnesium is usually chosen because it is a simple and accurate test.
5. Plot the data and check for reasonableness. It is a good idea to measure the level of the pond at each of the four corners each day and check the measurements for reasonableness. The data should correlate with the weekly pond measurements.

Total Magnesium in the pond at the beginning of the test should be the same as magnesium at the end of the test. If not, there is leakage, and the amount of magnesium lost will proportional to the leakage rate. The calculation is a straight forward material balance. The accuracy of the balance is a function of the care, technique, and accuracy in taking the data.

The author has used this method many times and has detected leakage rates low as 0.15 millimeters per day.

If salt is forming in the pond, the material balance must compensate for the salt layer and brine entrained in the layer. Salt floors tested by the author in many countries all contained 30 to 35 percent by volume of entrained brine. Other salts, such as sylvite, sylvinite, and epsomite have differing entrainment values.

3. EVALUATION OF SOILS.

A simple soils test will qualify soils for solar pond use. The test has been successfully used by the author at sites in the United States and abroad where ponds were constructed and operated. The soils under question are placed in a bottle and checked for settling rate.

The test is relatively quick and easy and can be done in the field without having to bring them into the laboratory. A bottle is used deep enough to hold 13 centimeters (5 inches) of liquid. The diameter is not critical, about 5 centimeter will work. The test is carried out in these steps.

1. Mark the bottle every 2.5 centimeters starting at the bottom of the bottle.
2. Fill the bottle to the 5 centimeter mark with water.
3. Add the soil to be tested until the liquid level rises to the 7.5 centimeter mark.
4. With a stirring devise, disperse the soil sample into the liquid. Some tight clays will require several minutes of agitation to disperse in the liquid.
5. Fill the bottle up to the 12.5 centimeter mark with more water.
6. Place the lid on the bottle and shake vigorously.
7. Let the bottle stand for three hours.

The soils will immediately begin to settle and an easily defined interface between the liquid and settling soil will be seen. The speed at which this interface moves down the bottle is a function of particle size and will directly relate to the soils suitability to prevent leakage in solar ponds.

If the interface moves down 2.5 to 5 centimeters (1 to 2 inches) in three hours, the soils will likely be excellent to prevent leakage in solar ponds. Soils this good are rare. Typically good soils will move down 5 to 7.5 centimeters in three hours. Sand and course particle soil will move down to 10 centimeters almost immediately.

This test will quickly qualify soils in the field, and help define areas with poor soils, marginal, good and excellent. Selected samples can then be brought into the lab for more testing if needed.

4. LEAKAGE PREVENTION.

4.1 Leakage through and under dikes.

Leakage through and under dikes is a common occurrence. Dikes built over salt floors or sand layers, streams and lenses will usually leak badly. A common and relatively inexpensive fix is with a slurry trench often called a "cutoff wall." The trench is made with an excavator fitted with a narrow bucket. The bucket is custom made such that the hydraulic hoses and fittings on the boom connected to the bucket will just clear the trench. If a normal bucket or wide bucket is used, the trench work will be slow and work will be difficult to impossible.

The excavator digs down through the dike from the top and mixes the soil in situ. Clay under the dike is brought up and mixed with the dike soil in the trench or, if no clay is layered under the dike, clay is imported. The dike soil, even though it is large grained and rocky, is not removed from the trench but mixes with the finer soils. Some times water must be brought in to make a mud slurry.

The author has seen hundreds of kilometers of dikes successfully sealed by this method.

4.2 Sealing marginal soils.

Tests conducted at Great Salt Lake Minerals Corp. in the 1970's, and testing facilities in Argentina showed that leakage could be reduces if soils were treated with lime. The lime reacts with magnesium in the brine to form very fine particles of magnesium hydroxide which seal the soil.

Treating brine with lignin (wood sugar) was also found effective in certain ponds treated with 70 ppm. The lignin is very stable however, and will color any crystallizing salt with a brown tint. The procedure cannot be used if a brown tint to the salt is undesirable.

Some brines may be treated with a fertilizer to stimulate biological growth (see reference). Such biological communities will seal floors and the method is used in many sea salt operations.

5. REFERENCES

H.L. Bradley, Guidelines for The Establishment of Solar Salt Facilities. Published by The United Nations Industrial Development Organization (UNIDO) 1983.