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# Design and Maintenance of Cisterns

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# Agricultural Engineering Update



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AEU-43

## DESIGN AND MAINTENANCE OF CISTERNS

E. Holmes and J.L. Taraba

- I. Design concepts: (See Figure 1)
  1. Water tight inside and outside
  2. Manhole or other covers tight to prevent contamination with 2" raised curb
  3. Overflow with check valve
  4. Initial roof-off diverted from cistern as roof dirt is washed off
  5. Inlet pipe near the top with splash pan below or a force breaker at bottom so that floor settlements are not disturbed. No data on which is more effective.
  6. Cleanout outlet pipe to pump located in small sump area with floor sloping to sump.
  7. Placed below ground to prevent freezing
  8. Water pipe to hose from floating inlet or 4" off bottom
- II. Materials of construction
  1. Reinforced concrete
    - Select an approved cistern design of the size desired (described later)

- Use a stiff 1-1/2-3 mix for concrete. One study showed that rounded shingle gravel was better than crushed gravel when watertightness was needed as in cisterns.
  - If gravel must be used it should always be prewashed to get best cement contact.
  - All steel rods should hook at corners and ends. Never use any rods except rebar.
  - Remember that quality concrete is a must but there is no substitute for good workmanship such as proper steel placement and working out honeycombs.
2. Concrete block cisterns
- Will not have the strength of a well designed and built concrete reinforced cistern. Each run of blocks should have steel horizontal joint reinforcement locked at each corner.
  - Running walls that exceed 12 feet should have a bracing pilaster (double crisscross blocks with each course filled with 3/8" rebar and concrete.
  - For either cistern a reinforced concrete top is recommended as it strengthens the cistern from top collapse and is easy to seal against contamination.

3. Wall Treatment

A tile drain is recommended around the outside base to relieve wall pressure and reduce contaminated groundwater from seeping into cistern if it is leaky.

Exterior walls

- A. Plaster coating of a 1-3 fine cement and sand using two coats on inside and outside walls. There are many commercial mixtures using special added ingredients, plastercizers etc. not known to be better than plaster.
- B. Black plastic sheets covering all walls in a continuous run are quite effective. Its weakness is deterioration unless completely earth covered. Also very hard to keep in place while back filling around exterior walls.

The A. item is the only one recommended so long as any of the commercial treatments are safe. Some cistern builders have successfully used a fine cement water mix scrubbed on with a brush. Again, commercial mixes may have certain additives. (Check label for approval for potable water.)

III. Wall Cleaning

Interior treatment always exposed to the drinking water can use only the cement sand mix or the special scrub on cement powder and water or approved commercial material. Since concrete and plaster will give taste to water for quite a long period the following treatments can minimize this taste, also one of these treatments should be used about every other year to discourage bacterial growth and keep clean walls.

The following are cleaning options:

1. 3 parts vinegar to 1 part water left on for 36 hours
2. 2 pounds baking soda dissolved in 2 gallons of water and left on 36 hours (personally I think not too effective)
3. 10% muriatic acid solution left on 4 hours

After treatment flush the interior with clean water and hose and thoroughly remove.

IV. Sizing cistern and catchment area (roof)

Family members use 50 to 75 gallon per day on average. Expecting a family of 4 with cistern to be conservative an example will use 50 gpd. A cistern holding a 60 day supply is a good size for KY. This family needs a 12,000 gallon cistern. If round, its size has a depth of 8' and 16' diameter. If square it has a 10' depth and 13' side lengths.

With KY rainfall varying from 40 to 50 inches per year and conservatively using 40 inches the roof area needed would be 4300 square feet. This presents a problem for many families as they have about 1/2 that roof area unless they have barns to compliment the house area.

The typical family with smaller roof area will haul water when rainfall is not ample. A common mistake with roof guttering is to select gutter that is too small wasting much water during heavy rainfall. The gutter should be at least 5" and have a leaf screen over it (Figure 2). The strap gutter is more durable than the nail-spacer type. Gutter is available in galvanized metal, aluminum and plastic. Galvanized is the strongest to stand up under snow loading but will rust.

Asphalt or asphalt fiberglass are the most common roof materials. Some lower income families had metal roofs. Logic would seem that contamination of the runoff water would be less with metal roofing since it is smooth. An Arizona study could find no evidence that deterioration of catchment materials would cause contamination of the run off water. The materials Arizona used was Rubberized asphalt, asphalt-fiberglass, Resin-fiberglass, aluminized asphalt fiberglass and sheet metal.

V. Roof prewash and cleaning systems

A Northern KY study showed that only 2 of 30 families used a roof prewash or diverter. There is strong evidence that such a unit is helpful in minimizing contamination.

The least cost prewash unit is a diverter valve left open to always flush off roof when a rain starts. The fault of this is its wastefulness. People may forget to close valve after the rain starts or they may be gone from home and lose the total rainfall.

A prewash unit that eliminates the problems above is sized to 10 gal per 1000 FT<sup>2</sup> catchment and does not allow water into the cistern until the barrel is almost full. A bottom trickle drain prevents freezing (Figure 3). A sand filter (Figure 4) used with a prewasher will make for a much cleaner water. The sand filter must have at least 4 square feet of

surface area per 1000 square feet of roof area to handle the rainfall. The sand filter also requires periodic maintenance by cleaning the surface and backwashing.

#### VI. Cistern Water Treatment

Cisterns can be chlorinated after each rainfall but records must be kept of water added by rainfall to determine the amount of chlorine to use. A study in the Virgin Islands suggest the effect of chlorine lasts less than two weeks when bacterial populations return to high levels. This will help to control the bacterial growth on the cistern walls. One problem is that chloroform is formed when chlorination sits for a long period. However, this is easily removed with a carbon filter as the water is used. Chlorination at the time of use can eliminate the chloroform problem but not the cistern wall bacteria.

A Northern KY 2 year study with 30 family cisterns 68% had coliform in their water samples supporting the need for chlorination. The coliform count was always much higher when the water sample was taken off the bottom. Only 8 of the 30 families ever cleaned their cistern and 14 never used disinfectant. Those that used disinfection wadded a bottle of bleach once or twice per year.

Water collected from roofs has the potential of being contaminated by deterioration of by products of the roof materials, from dust deposited on the roof surface or impurities trapped by rain from the atmosphere. The Arizona study as previously mentioned found that roof materials was not part of the problem. However, they were very concerned with arsenic. It was the only chemical consistently found in the water samples at potentially hazardous concentrations for domestic drinking water supplies. They decided that arsenic was deposited on the catchment surface by dust or washed from the atmosphere by rainfall. The source of the arsenic was ~~not~~ found at the time of the report. With the exception of the arsenic other inorganic elements were well below the drinking water standards. Other elements found were cadmium, chromium, lead, Mercury, vanadium, aluminum, calcium, cobalt, copper, iron, Magnesium, potassium and zinc.

In a Pennsylvania study no mention was made of arsenic as a problem. Their main concern was lead as 11% of the 40 cisterns studies had lead exceeding the 50 mg/L drinking water limit for lead. Through cadmium, copper and zinc was studies levels were not high enough for problems. The bottom water with sediment have metal levels up to 20X that of water above the sediment.

The water in a number of cases had high enough acidity to be detrimental to pipes. Roof water filters (unspecified) produced a significant reduction in sediment metals contamination of cisterns. It was interesting but unexplained why 9 of the 40 units produced standing tap water with lead levels above the drinking water standard while running tap water concentrations all fell below the standards. This is due to corrosiveness of soft rainwater leaking metals from

lead solder and faucets.

KY uses many wood burning stoves and these make roof deposits. This is also true of coal burners. No study was found on what and how much of this material gets into cisterns. In the KY industrial and coal mining areas dust in the atmosphere obviously must enter cistern water. Without the wood burning and industrial air contamination during dry periods there is much dust from rural unpaved roads settling on roofs.

VII. Unanswered questions:

1. What are the potential materials that get into KY cisterns.
2. Are insecticides and pesticides polluting cisterns.
3. What are the danger levels when drinking contaminants in cistern water.
4. How effective are our present filtering and cleaning methods and what new designs can we develop to improve the quality of cistern water.
5. Are the non-coliform bacteria found in cisterns harmful? These bacteria have had little research as to their health effects.











