Deep Seepage Assessment in Small Reservoirs

Authors

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Scope: Questions and challenges

In some instances, increased demand for reliable water supplies for agriculture means that more information is needed on water storage in small reservoirs. The water storage provided by these structures depends upon interrelationships among water supply, losses, demand, and how all of these are distributed throughout the year. Evaporation and seepage are the main losses. Evaporation is relatively easy to estimate but seepage is not. Seepage is sometimes not even considered in calculating reservoir water balances because it is considered so difficult to estimate or measure. However, a large number of small reservoirs in developing are sited where seepage losses are significant. Seepage, in those cases, can reach values as high as 24 mm/day, representing a significant component of the water balance. It is therefore important to understand the seepage behavior. The objective of this tool is to provide a simple methodology to measure seepage losses through the bottom of small reservoirs.

Target group

Water planners, engineers, managers and other experts

Requirements for application

A seepage barrel and a scale

Meteorological data, ground elevation data (measured by using a standard level and stadia rod), piezometers, and information about the subsoil are also useful

Description and application

Seepage barrel construction:

The seepage barrel, Figure 1, can be constructed using locally available materials. The main component consists of PVC pipe with a diameter of about 25 cm. The pipe is closed at the top and open at the bottom. About 10 cm below the closed end, a hole is made. An infusion bag (a medical infusion bag can be used) is connected to the hole by a rubber tube. The infusion bag should be attached in such a way that it can be taken off as needed. In the tube a valve is placed to close off the infusion bag when not connected to the tank.
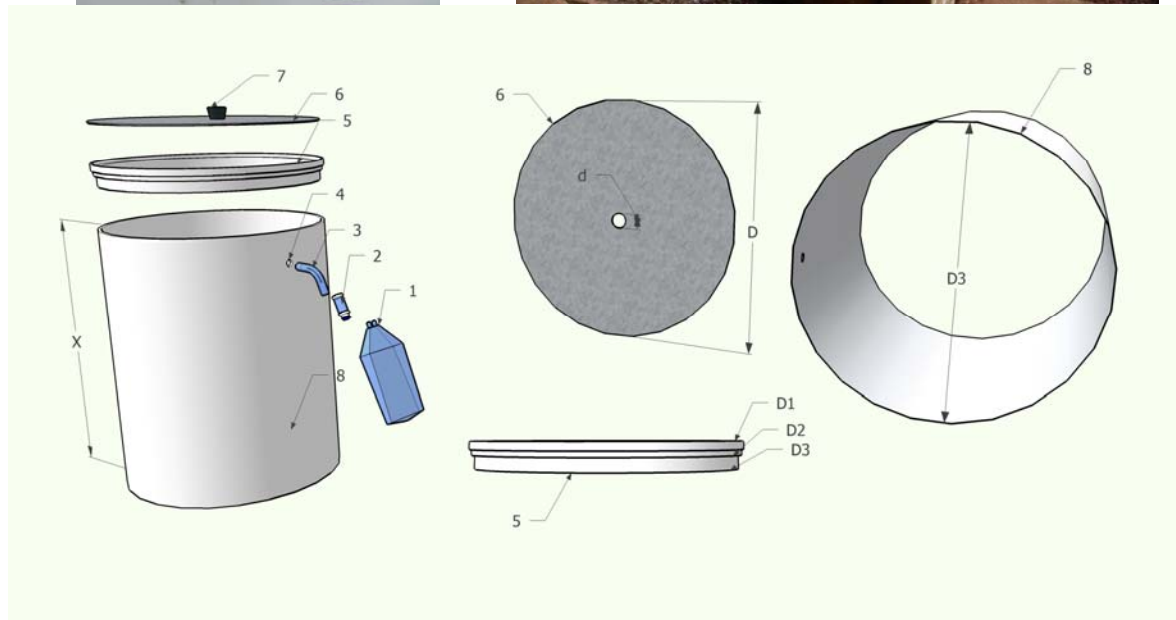
1, 2, 3	Bag, valve and rope (an infusion bag was used)	6	Lid (made of metal. D = 26 cm; d = 1.5 cm)
4	Hole (made about 10 cm below the top part of the barrel with a diameter of 0.5 cm)	7	Robber (it has a conical format, with one diameter being equal to 1.3 cm and the other equal to 2.3 cm)
5	Connection (D1 = 26.0 cm; D2 = 25.4 cm; and D3 = 24.7 cm	8	Barrel (made of PVC, with a diameter of 25.4 cm; the height varies with the depth)

Figure 1 - Photo showing seepage barrels built and parts draw schematically.

A hole is drilled in the closed end of the pipe. A rubber stopper is used to close this hole. The top of the tank should be constructed in such a way that the hole is located at the highest point in the system so that any trapped air will collect near the hole and be released through the hole when the stopper is not in place.

Installation procedure

The equipment is used to measure seepage directly. First identify the place where seepage is to be measured. Fill up the infusion bag with water from the reservoir and weigh it. Before immersing the pipe in the water take the rubber stopper out. The open end of the pipe is pressed into the bottom of the reservoir closing off a section with a known area. Close the hole on the top with the rubber stopper. The infusion bag is flexible. Therefore the pressure inside the bag is the same as the pressure in the water surrounding the bag.

Figure 2 – Photo showing seepage barrels installed in the reservoir.

Seepage calculation: The bag was connected to the tank, which was completely submerged and filled with water. After some time, the bag was disconnected and re-weighed. The seepage rate may be positive or negative. Seepage, in minutes, was calculated using equation 1:

$$S = 0.06 \frac{\Delta M}{A \, \Delta t}$$

(1)

where: ΔM is the difference in mass over the measurement, g; A is the pipe cross section area, m^2; and Δt is the time over which the measurement was taken, min.

Seepage measurements: Case study of the São Francisco Basin, Brazil

This tool was used to measure seepage in a small reservoir in the Buriti Vermelho catchment, a subcatchment of the São Francisco Basin, Brazil. The reservoir is typical of those found in the upper part of the São Francisco Basin. It has a surface area of about 0.5ha and is used for irrigation by a small community of farmers. Seepage barrels were installed in such way as to get a good representative sample of the spatial variability of seepage in the reservoir (see Figure 3).
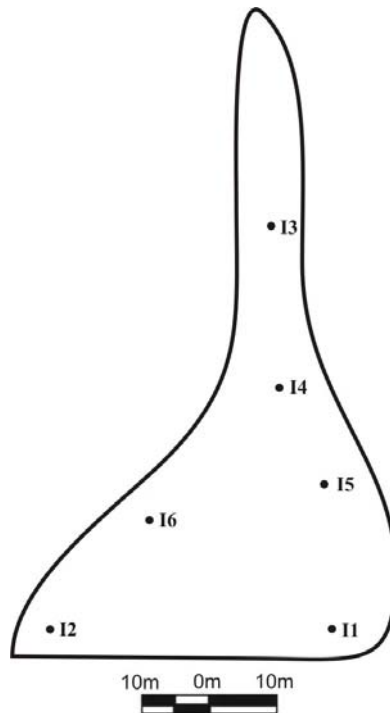
Figure 3: Schematic representation of reservoir number 2 and the locations of the direct seepage measurements.

Seepage barrels were built as described above. Infusion bags were filled with water from the reservoir and weighed. Then they were connected to the seepage tanks and the valves were opened. After a few hours the valves were closed and the bags were weighed again and the two weight measurements compared. Seepage was measured at six locations in the reservoir, as shown in Figure 3. Several measurements were taken at each location. Average seepage rates (mm/h) at sampled locations were: I1 = 0.4643; I2 = 0.3979; I3 = 0.1145; I4 = 0.7741; I5 = 1.0646; I6 = 3.9375 (average = 1.12 mm/h). This value is about half of the average evaporation in the region and is 1.26 times greater than the reservoir storage capacity. It means that around 4,032 m^3 of water leaves the reservoir per month. The results demonstrated the importance of seepage in calculating water balances, and the importance of spatial and temporal variability of seepage within a reservoir. The difference in seepage rates between the highest and lowest values is on an order of magnitude of about 35.

Lessons learned

Experience was gained in measuring seepage. It is important that its high spatial and temporal variability be better understood. The tool described herein should work under many conditions, though there may be practical problems to overcome. These must be confronted when the tool is applied.

Recommendations

1. To get better insights into the temporal variation of the seepage, direct seepage measurements should be taken over a longer period, and in more than one location.

2. It is important to verify that the closed parts of the barrel do not leak.

2. Measuring seepage should become a standard practice in small reservoirs: seepage can represent a large loss of water.

3. It is wise to continue measuring seepage and record any problems with their solutions.

4. Seepage estimates for a small reservoir obtained by using the proposed tool should be cross-checked with those obtained from the water budget method (IN – OUT = ▲S).

Limitations

Direct seepage can be measured with a seepage barrel, but the high spatial variability of seepage calls into question the representativeness of any particular measurement. It is important to get an idea of the order of magnitude of seepage, and its spatial variability.

References

Dekker, T. (2007). Modeling the Buriti Vermelho catchment – In search of the best model with low data availability. Delft University of Technology. MSc.

Contacts and links

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