AUTOMATIC DOSING SIPHON OPTIMISATION AND USE: A NON THEORETICAL APPROACH

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Abstract

Automatic Dosing siphons are able to turn constant or irregular flows into calibrated doses. This is particularly useful where it is desirable to transform low flows into doses that pressurise a distribution manifold or drainfield emitters or where dose/rest cycling is required. With no moving parts and no need for electric power, they can, subject to adequate falls, replace electric pumps. This paper reviews field work associated with dosing siphon design and development for use in an experimental low cost sand filter (Geary *et al.*, 2001). Siphon triggering and resetting failures, in the field, of siphons intended to dose the sand filter and drainfield led to an experimental testing of several aspects of siphon design. Prototypes were made in which proportions of the siphon components were varied until reliable triggering and resetting occurred under conditions encountered with domestic wastewater systems. The principles of siphon operation are outlined in this paper together with descriptions of triggering and re-setting failures. Suggested remedies are discussed.

Keywords

automatic dosing siphon, balance tube, bell, trap, triggering

1 Introduction

An automatic dosing siphon is a very simple apparatus. Set within a collection tank, it consists of a device to trigger siphon action when water (or other liquid) rises to a predetermined level, and a siphon pipe to discharge the water much as an electric pump would. It also has a balancing device to re-set the siphon in readiness for the next cycle. In this way the apparatus automatically continues cycling.

Automatic dosing siphon technology is over 100 years old (Ball 1996). Siphons have been used for automatic urinal flushing, stockyard cleaning and in sewerage treatment systems- particularly with sand filters requiring periodic dosing. They are useful wherever variable or continuous flows are required to be turned into regulated, intermittent doses. However, their use in Australia in domestic and small-scale wastewater treatment systems is minimal. There are no major manufacturers of automatic dosing siphons in Australia, possibly due to a low volume of demand. Siphons for domestic wastewater systems are made in low numbers or imported from America or New Zealand.

With a growing interest in alternative wastewater treatment systems it seems likely that dosing siphons will become more commonplace. This is particularly the case in New South Wales where interest in sand filters for domestic wastewater treatment is only now gaining momentum. Until recently, aerated systems have been employed to provide most Council approved on-site domestic wastewater treatment in unsewered areas. A number of sand filter-based systems have now been approved by councils in New South Wales. Automatic dosing siphons are particularly suited to intermittently dosing these sand filters where electric power for pumps is not available or is prohibitively expensive to install or, because they have no moving parts, in cases where maintenance may be difficult such as found in remote or infrequently attended installations. By installing siphons in lieu of electric pumps, on sites with suitable slopes, considerable savings in capital and running costs are possible.

2 Automatic Dosing Siphon Operation

The basic principles of the automatic dosing siphon operation are elementary. A bell-shaped device sits over a p-trap within a collection tank. The trap is filled to prime the siphon. As water level in the tank rises above the bottom of the open bell, air pressure developed within the bell displaces water in the trap. As the water level in the tank continues to rise, the air pressure in the bell also increases displacing more of the water in the trap until air in the bell is vented through the trap. Siphoning is triggered as water enters the bell to replace vented air.

Siphoning continues until the water level drops below the bottom of the open bell allowing air to enter the bell and break the siphoning action. The general arrangement of an automatic dosing siphon is shown in Figure 1 and its siphoning cycle (Ball 1996) in Figure 2a-e.

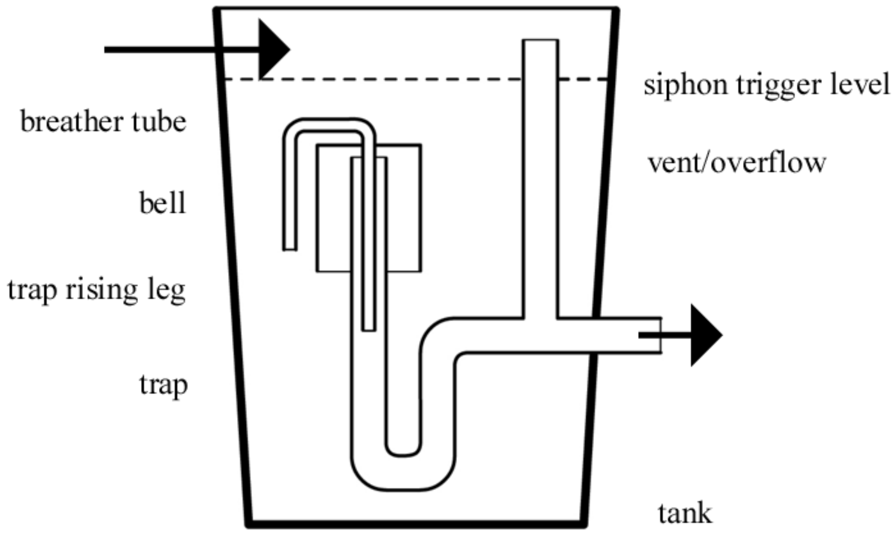


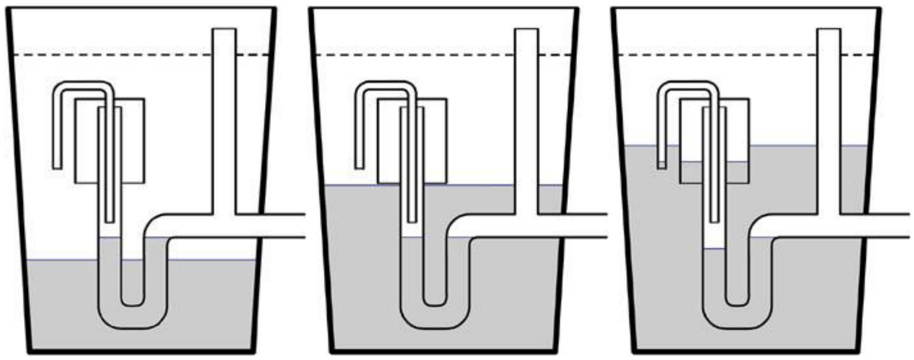
Figure 1: Typical Automatic Dosing Siphon

Siphons for use in domestic wastewater treatment systems typically have outlet pipes ranging in size from 50 mm to 100 mm diameter although larger sizes are available. The volume of water discharged depends on the tank size and top and bottom levels of the siphon cycle but is typically between 70 L and 200 L. These siphons are specifically used for dosing as compared to the larger scale non-trapped siphons, typically found in dam construction, used only to maintain water levels within designed limits.

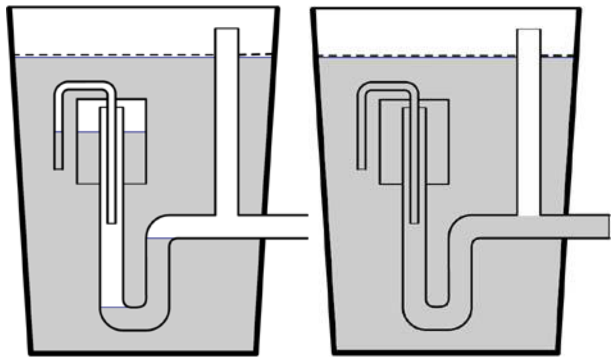
3 Modes of Failure

Without careful design, siphons tend to fail in one of two modes. Firstly, they can fail to fully trigger the commencement of siphon action and secondly they can fail to reset at the end of the siphoning cycle. In both cases the dose/rest cycling action discontinues and water entering the tank passes through the siphon and discharges at the same rate as it enters.

Triggering failure typically occurs when very low inflow rates only partially initiate siphoning. This is usually due to air leakage or a trap that is too shallow to reliably prevent air bubbling through it. Under these circumstances the low inflow rates are inadequate to drive the siphon resulting in a steady state being reached where air trapped in the bell is at atmospheric pressure and the water in the rising leg of the trap is not displaced. Until the siphon is reset, by lowering the tank water level below the bell level, any inflow is matched by outflow and the siphon simply acts as a conduit with no periodic dosing action (refer to Figure 3).



a) Trap Primed **b) Start (and end) of cycle** **c) Bell and balance tube sealed trap water partially displaced**



d) At the Point of Triggering **e) Trap vented, siphoning started**

Figure 2a-e The Automatic Dosing Siphon Cycle

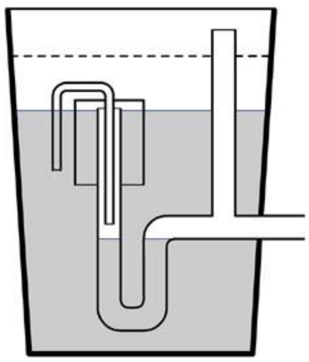


Figure 3 Triggering Failure

Tickling inflows are matched by trickling outflows

Resetting failure occurs at the end of the cycle when sufficient air is admitted to the bell to break the siphoning action but not to evacuate all the water and fully recharge the bell with air. Air pressure in the bell becomes negative and holds the water level, inside the bell, higher than that outside (refer to Figure 4). As water level outside the bell rises the water level inside the bell reaches the top of the rising p-trap tube and outflow matches inflow. Again the periodic dosing action no longer occurs until intervening action is taken.

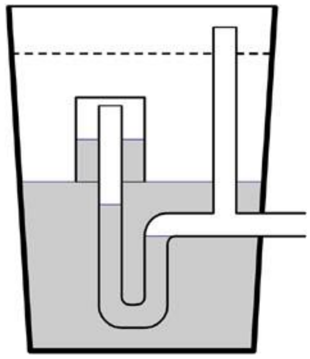


Figure 4 Resetting Failure

As water level rises the siphon reaches a steady state as shown in Figure 3

4 Siphon Optimisation

Reliable triggering appears to be largely a function of proportion. Most automatic dosing siphons have a bell volume to trap volume ratio of about 3:1 and a bell diameter to trap pipe diameter ratio of 3:1 or greater. The depth of the trap is also important. As trap depth increases (without necessarily increasing the bell height) the water level within the tank, at which the siphon action is triggered, becomes higher. This is a useful way to control the volume of each dose. However, based on trials of various trap configurations it appears that deeper traps trigger more reliably, particularly at low inflow rates. As trap depth is decreased, the rate of inflow required to reliably trigger the siphon action appears to increase and the siphon becomes unsuited for use where low inflow rates may be experienced. However, a correctly sized trap will ensure that a siphon, with a discharge pipe size up to 100 mm diameter, can trigger at inflows of less than 1 L/min.

Reliable resetting, at the end of the siphon cycle, is achieved by using a balancing tube to fill the bell with air at the same pressure as air outside the bell. To optimise resetting, the balance tube ends need to have a carefully calibrated relationship with the level of the bottom of the bell for the outside leg of the tube and the top of the trap water level for the inner leg.
The end of the outer leg of the balance tube should be clear of the water level in the tank at the end of the siphon cycle, that is, above the level of the bottom of the bell. The end of the inner leg should be as deep into the trap rising leg as possible but clear of the trap high water level. Because the end of the inner leg of the balance tube is within the siphon stream at a point below the bottom of the bell, siphoning action continues beyond the level of the end of the outer leg until water level in the tank falls below the bottom of the bell. When air enters the bottom of the bell and breaks the siphoning action, water level inside the trap rising leg falls below the end of the balance tube inner leg leaving both ends of the balance tube open to atmosphere. This ensures that the bell is reset and the siphon, as shown in Figure 2b, made ready for the next cycle to commence.

5 Results

An automatic dosing siphon has been developed , based on the above experimental observations, for use in domestic wastewater treatment systems. It is reliably triggered by inflow rates as low as 0.2 L/min (lower inflow rates have not been tested) as well as by interrupted, varying and high inflows. It also reliably resets at inflow rates of 30 L/min (higher inflow rates have not been tested).

Specifically, the siphon has been designed for use in an on-site domestic wastewater treatment system as shown in Figure 5. The first siphon doses the sand filter while the second pressurises the drainfield sub soil emitters via a header tank. The dose size from the first siphon and the fall required to the sand filter depend on the design of the distribution manifold within the filter. Typically, for a sand filter of 20 m^2 top surface area, a dose of 100 L and a minimum fall of 1 m will ensure that the manifold is evenly pressurised.

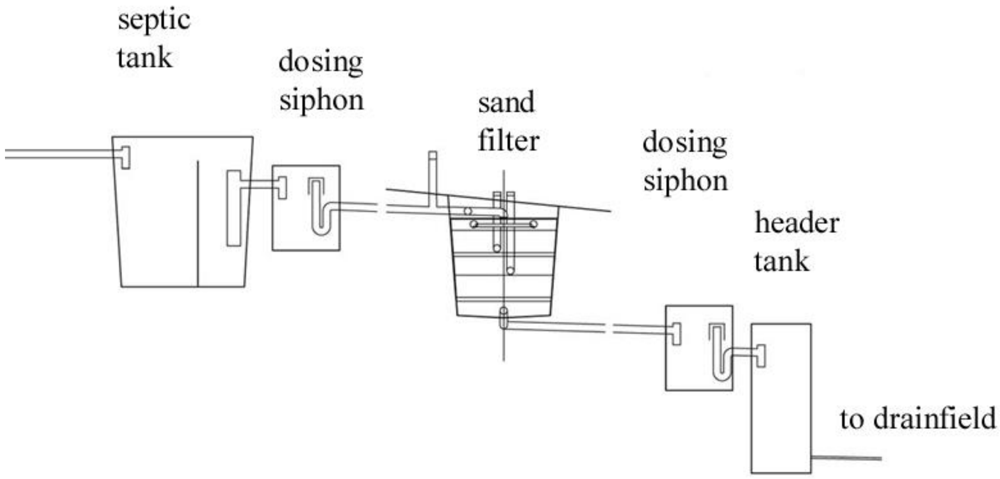


Figure 5 Domestic Wastewater Treatment System

Diagrammatic section showing sand filter and dosing siphons (Geary *et al*., 2001)

The dose size of the second siphon is determined by the desired frequency of drainfield dosing and the practicalities of the header tank size. The fall to the drainfield is determined by the head required at the emitters. This can be greater than 10m for some systems, necessitating the use of suitable pumps in lieu of the siphon if sufficient fall is not available.

6 Future Developments

To further optimise the operation of automatic dosing siphons, future research will concentrate on aspects of bell form, tank proportions and form. Most bells are cylindrical, probably for ease of manufacture, but spherical or conical forms may contribute to more reliable triggering and assist in smoothing the flowpath into the p-trap. There also appears to be a relationship between the surface area of water in the tank at the moment of triggering and the rate at which full siphoning is achieved that will be investigated. It is possible that an inverted cone-shaped tank will assist triggering while minimising the trap depth required for reliability.

References

Geary, P. M., Stafford, D.J., Spinks, A. and Whitehead, J. H. (2001), 'The Use of Clinoptilolite in a Low Cost Aerobic Sand Filter'. Paper to be presented at *On-site 01: Advancing On-site Wastewater Systems, Design and Maintenance*, Armidale, 2001.

Ball, E. S. (1996), *Design, Use and Installation of Dosing Siphons for On-site Wastewater Treatment Systems*, Orenco Systems Inc., Sutherlin, Oregon.