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Recording surface runoff in the field: a simple detector made of polypropylene

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A B S T R A C T

Surface runoff is an extremely important hydrologic flowpath since it transports soil and pollutants. For this reason, low cost methods are needed to detect such process in the field. In the present paper, we present a simple surface runoff detector made of polypropylene. Its low cost along with its high repeatibility allow for the use of a high number of detectors in the field to elucidate spatial variability as well as to trace overland flow route. Simple demonstrations of the method are provided. With this simple detector, more knowledge can be obtained on this important hydrologic pathway which is related to soil erosion and transport of a number of potential harmful substances to water bodies.

Keywords: Soil conservation, Water contamination, Soil loss

Introduction

Surface runoff, also known as overland-flow, is a hydrological process that occur on soil surface when: (i) soil is water saturated (Dunne and Black, 1970) and (ii) when rain intensity exceeds soil infiltration capacity (Betson, 1964). The former is known as saturation overland-flow whereas the latter is known as Horton overland-flow.

Regardless of its type, the occurence of such hydrological process is associated to soil and water degradation (van der Laan et al., 2017). Water degradation specifically occurs through the transport of both particulate (soil minerals and organic matter that make up the soil matrix) and dissolved (soluble organic matter, herbicides, pesticides, fertilizers, and others) materials that, ultimately, reach water bodies changing their physical (color, turbidity, electrical conductivity) and chemical (pH, composition) characteristics (Altenburger et al., 2015).

These changes bring about consequences for both terrestrial and aquatic ecosystems as they are, respectively, the source and the final destination of these materials.

Various forms of detection and mesaurements have been used for surface runoff including plots (Ulrich et al., 2013) and detectors (Zimmerman et al., 2014). Yet, given the importance of such process, simple, unexpensive and practical detection in the field must be looked for rural landowners, researchers, enviromental and agricultural agencies, and enviromental managers as a whole. This is especially relevant when hazardous materials are stored in areas subjected to surface runoff generation (Agnew et al., 2006; Walter et al., 2013; Subhasis et al., 2016).

In this context, in the present paper, we present a low-cost surface runoff detector which, for this reason, can be widely used for those interested in detecting such hydrological processes in the field. Details and installation tips are provided.

Methods

Development

The surface runoff detector can be made of oftentimes wasted materials such as plastic packages. In the present paper, plastic packages of dairy products (cream cheese) are demonstrated for two reasons: (i) low cost and (ii) possibility of reuse (Figure 1). To produce such detector, it is necessary to use a knife to perform to lateral holes (~2 cm) in the cup perimeter (Figura 1a,b). Such holes have to be located ritgh below the cap (Figura 1b).

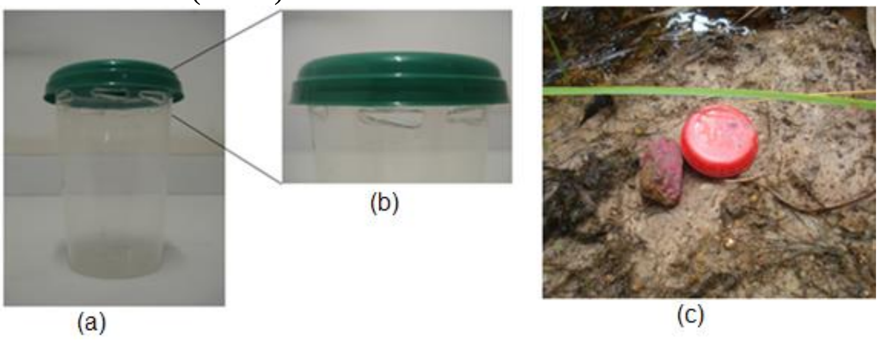

Figure 1. Surface runoff detector (a). Note the lateral holes right below the cap (b). Such holes allow water to get in the cup while the cap prevents the direct entry of rainfall. Surface runoff dectector installed in the field.

Fied installation

The field installation of the device can be done with a small gardening shovel which will be used to dig a hole in the soil where the device will be accomodated in terms of both depth and diamater. When digging, one has to minimize soil disturbance in order to preserve soil structure as much as possible. The detector must be inserted into the soil until the level where lateral holes are at soil surface (Figure 2)
.

Figure 2. Surface runoff detector installed on the soil surface. Note the hole of the dectector is leveled relative to the soil surface.

Once the device is installed, surface runoff can dectected when lateral holes allow water to enter the cup. Thus, after such rain event, the detector will be filled in case surface runoff has been generated. Therefore, this is a binary surface runoff detector (Figure 3). After a field campaign, it is ncessary to empty those detectors which were found filled with water. Subsequently, the detector should be reinstalled in the same place. The cap should be kept at all times in order to prevent direct rainfall/throughfall to get in the device and, as a consequence, provide a false positive detection, that is, rainfall (instead of surface runoff) filling the detector.

Figure 3. Detector filled with surface runoff water after a rain event.

Field tests in places prune to saturation overland-flow generation indicated that it is necessary to add a body of at least 500 grams since the rise of water table may eject the low density detector (polypropylene). In this respect, gravel (5-10 cm) usually found in the field can be a useful option.

Application

The advantages of this dectetor are: (i) low cost which allow for a high number of samples in the field which, in turn, allows one to understand spatial variability and frequency of surface runoff (Figure 4). Furthermore, its low cost also makes its replacement in the field an easy task when wildlife and other factors remove or damage them (e.g. fire, vehicles). After a sequence of rain events, it is possible to count the frequency of overland-flow of a given locality. For example, in a place where surface runoff was detected 7 out of 10 events, one can conclude that such area has 70% of probability of surface runoff occurence in such period.

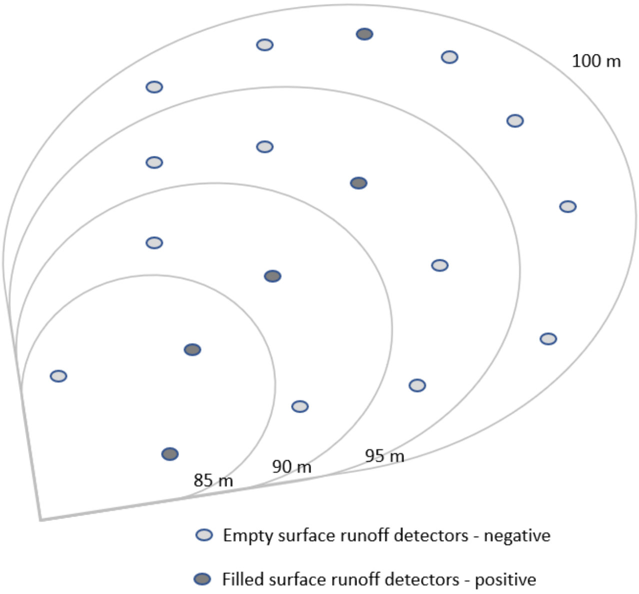

Figure 4. A net of surface runoff detectors in a concave slope. Numbers indicate contour lines. Black points denote positive detection. One can trace the likely surface runoff route by following black points from upslope to donwslope positions.

Educational purposes

Given that such device can be produced easily, it can also be used for educational purposes with students of all ages during both the preparation (before field installation) and after (sampling). Regarding the former, students can help in finding plastic glasses as well as in building the holes in such plastic recipients. As for the latter, they can (i) learn and help to install in the field and (ii) check for the presence or absence of surface runoff detection. Moreover, sampling design and number of samples can be discussed and calculated by graduate students.

Final remarks

A simple, practical and low cost detector of surface runoff is shown here. Its use encampass a wide range of applications (from dectection in the field as well as educational purposes).

Finally, one can use the water within these detectors to understand what chemicals are being transported by surface runoff. Nonetheless, before doing so, there has to be some tests to check for polypropylene is inert (see Likens and Eaton, 1970).

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