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Infiltration Assessment for Better Watershed Management in Northern Mexico

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INTRODUCTION

Watershed management for getting water resources requires accurate measurement from water cycle compartments. Some process conditioning water supply and hydrological transfers such as: rainfall, runoff, infiltration, deep percolation, evaporation, water up-take and transpiration by plants, should be quantified for improve watershed management.

This paper shows an infiltration assessment realized in the upper watershed of Nazas River. This watershed is the main source of water for irrigated agriculture in northern Mexico that is actually submitted to a strong productive pressure for forestry and cattle breeding production causing environmental disturbs with important hydrological impacts.

STUDY AREA

The upper watershed of Nazas river has an area of 18 321 km^2 in a mountain zone within 1600 and 3200m altitude (figure 1). It has a semiarid to sub-humid climate with a year rainfall from 500 to 900mm. The Nazas river drains 35 577 km^2 with a perennial flow regime characterized by a low discharge period, up to 8 m^3 s^{-1}, from November to June and a maximum discharge period, up to 74 m^3 s^{-1}, from July to October. The watershed's geology is dominated by Rhyolite, Ignimbrite and volcanic Tuffs forming shallow and sandy Leptosols, Regosols and Cambisols (Gonzalez Barrios *et al.*, 2007). The main vegetation is a pine-oak forest with grassland. The main productive activities are forestry and cattle breeding.

MATERIALS AND METHODS

Three representative sites of soil surface in the upper watershed of Nazas River were chosen for infiltration assessment. They can be related with the main natural and disturbed area features (Descroix *et al.*, 2007): Forest surface with pine-oak humus (figure 3); Grassland surface with *Bouteloa gracilis* (figure 4); and Almost bare and compact surface related with disturbed areas of high intensity activities for forestry and cattle breeding (figure 5).

Triple Ring Infiltration Method (Vandervaere, 1995; figure 2) was useful for measuring infiltration rates with three discs of different radius (4, 9 and 12 cm) under constant water charge conditions, and four suction forces imposed to soil (-100, -60, -30 and -10mm). Other complementary parameters such as: soil texture, soil water content and bulk density, were observed as well.

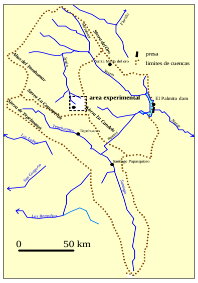


Figure 1. The upper watershed of the Nazas River

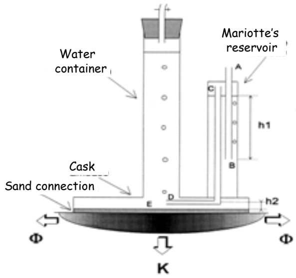


Figure 2. Disc infiltrometer

Figure 3. Grassland surface

Figure 4. Forest surface

Figure 5. Disturbed surface

RESULTS AND DISCUSION

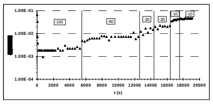
Figures 6 to 8 show the infiltration rates on each soil surface. In all tests, infiltration flux decreases quickly at the beginning, then it fluctuates until a certain stabilized value; this stabilization could be related to a steady state. Suction force is then reduced and infiltration flux increases again until a new stabilized value. This operation is repeated for all different suctions in order to determine soil functional porosity. Infiltration flux generally increases when imposed suction forces diminish but, this is not happened on forest surface (figure 7) where infiltration flux did not increase when suction force has been changed from -100 to -60mm and -30mm. Forest surface showed a water repellency behavior until the 16000th second when infiltration flux increased suddenly, certainly because humus surface became wet. Late measurements with increasing suctions forces showed an irreversible effect (hysteresis) on infiltration rates.

Differences on infiltration rates along the suction forces applied can be related with soil surface nature and porous media structure (Domergue, 2006).

Grassland surfaces show infiltration rates from 8 to 166 mm h^{-1} (from -100mm to -10mm suction force applied, respectively) reflecting a good structured porous media in soil (figure 6). Functional porosity into soil is ordered and quite connected since micro-porosity is well relayed by middle and macro-porosity along the infiltration test. Soil reacts as a high permeable body for hydrological transfers into deeper water cycle compartments.

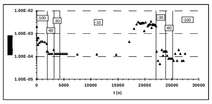
Forest surfaces show infiltration rates from 0.5 to 9 mm h^{-1} (figure 7) with a repellent phenomenon at the beginning of the test, certainly linked to the abundance of pine-oak humus with many water repellent compounds from aromatic and aliphatic origin; moreover, dry initial conditions in soil humus increase repellency to water. Nevertheless, functional porosity into soil seems to be ordered as well as grassland surfaces. Soil reacts as a permeable body when humus is completely wet.

Disturbed soil surfaces show infiltration rates from 60 to 127 mm h^{-1} with almost no difference between infiltration fluxes under the suction forces applied (figure 8). This reflects not well structured porous media in soil. Infiltration fluxes and rates are disordered and do not show good connection in functional porosity along the suction forces applied. Soil reacts as a low permeable body for hydrological transfers.



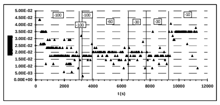
Suction force applied (mm)	-100	-60	-30	-10
Final infiltration rate (mm/h)	8.13	27.36	73.44	166.68

Figure 6. Infiltration on grassland surface



S.F.A. (mm)	-100	-60	-30	-10	-30	-60	-100
F.I.rate (mm/h)	1.71	0.5	0.47	9.10	0.57	0.31	0.35

Figure 7. Infiltration on Forest surface



S.F. applied (mm)	-100	-60	-30	-10
Final Inf. rate (mm/h)	60.84	63	60.84	127.08

Figure 8. Infiltration on Disturbed surface

CONCLUSIONS

Infiltration are quite different depending on the state of the soil surface; grassland and forest surfaces show more permeable conditions to water transfer than disturbed surfaces.

These states of soil surface reflect conditions of natural or managed environments in the upper watershed of the Nazas River. Repercussions of increasing disturbed areas could be easily imagined in terms of groundwater recharge, runoff and soil erosion as well as water quality yield. It is important to control the high intensity areas of forestry and cattle breeding production for limiting their hydrological impact.

This work shows the importance of doing an accurate infiltration assessment, in order to encourage best management practices inducing better watershed management for getting water resources.

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