Hydrodynamic behaviour of Segura River basin soils: Effects of texture and moisture contents

Antonio Sánchez Navarro[A] , Purificación Marin Sanleandro[A], Mª José Delgado Iniesta,[A] Maria García González[A], Arantzazu Blanco Bernardeau[A], Juana María Gil Vázquez and **Roque Ortiz Silla[A]**

Agricultural Chemistry, and Pedology Dept, Faculty of Chemistry, University of Murcia, Murcia, Spain. Email rortiz@um.es

Abstract
Soil physical and chemical properties determine the hydrological behaviour of soil. From this hypothesis, the objective of this study was to establish pedotransfer functions able to determine soil hydrodynamic characteristics from the analytical data available in the current soil maps of Segura River watershed. The range of values and the average of every soil parameter were estimated for every soil type. In this work, granulometric characterization was carried out in addition to water retention capacity at 1/3 and 15 atm pressure to 685 arable soil layer samples corresponding to surface A horizons from the soil profiles. It was proven that these parameters did not show important changes on most predominant soil types of the area, being only different in Arenosols, Cambisols, Vertisols and Fluvisols. Therefore, hydrodynamic behaviour of these soil types must be influenced by those parameters.

Key Words
Hydrodynamic properties, FAO soil units, texture, water retention capacity, semiarid soil.

Introduction
Water flow and availability of the soils-plant-atmosphere system is controlled by its hydric and hydrodynamic properties. The soil water behaviour is conditioned by physical properties and the chemical properties affecting to soil physical characteristics. Soil surface characteristics regulate water distribution in the hydrological cycle. In this way, soil water has a dynamic behaviour whose understanding achieves a key importance, mainly in areas with serious water stress as it occurs in the Segura River catchment.

A very important soil function, as a component of the ecosystem, is the collecting, storage and control of water dynamic within soil profile. This soil function is fundamental for biomass productivity and suitable environmental conditions. An appropriate soil infiltration increases the soil capacity for the storage of available water for plants and aquifers recharge with the decrease as a consequence of runoff and soil erosion. Soil water movement and storage are controlled by the structure of surface soil horizons. Crust formation and soil compaction could lead to soil sealing. (Duley 1939 ; Morin *et al*. 1989).

In this study the soil granulometric characterization and soil moisture retention at 1/3 and 15 atm from the A horizons of 685 soil profiles were accomplished. From these data base an estimation of the effects of above mentioned parameters on hydrodynamic soil properties of the Segura River Basin was carried out.

Methods
Study area and previous data
The study was carried out in the Segura River Basin (Murcia, Spain) from the data base constituted by soil parameters of surface horizons (A) of soil profiles studied in the LUCDEME Project (Fight against the desertification in the Mediterranean, 1983-2006).

Statistical methods.
The data were statistically treated using the R software. When conditions of normality and homoscedasticity could be assumed, an ANOVA test was carried out to compare means; otherwise a non-parametric test of comparison of ranges was applied (Wilcoxon Test)

Laboratory methods
Soils were classified following the "World Reference Base for Soil Resources 2006" (FAO-ISRIC-IUSS, 2006). Surface soil samples (0-30 cm) for laboratory analysis were sieved through 2 mm mesh. The following parameters were analysed: Water retention capacity was determined by membrane method (Richards 1941) at 1/3 atm (field capacity) and 15 atm (wilting point). Available Water (AW) was

considered the difference between water retained at pF 1/3 and 15 atm. Granulometric analysis was determined after total dispersion of soil samples by shaking with sodium hexametaphosphate at 5%. Sand, silt and clay fractions were isolated from the dispersed samples through decantation and extraction with a Robinson pipette.

Results

More than 40% of the total soil units in the FAO-ISRIC-UISS (2006) classification were differentiated in the Segura Basin (Figure 1) The most spreaded soil was Calcisols, covering 51% of the Basin area. The following in extension order were Regosols, Leptosols and Fluvisols covering 14,86, 14,24 and 10,93 of the surface area respectively. The other nine units constitute all together, only the 8% of the Basin area. There was evidence, out of this soil units distribution, of the predominance of soils with ochric epipedon, while the mollic epipedon was only evident in Kastanozems, Phaeozems and some Leptosol.

With regard to granulometric composition, in general the balanced textures prevail, with sand and silt averages ranging between 30 and 40% and clay about 20%. However, a more detailed analysis of the data showed clear differences among some of the main soil units. In this way, the highest differences occur in Arenosols, which, as can be expected, have a very coarse texture, being the sand average near 95% of the total mineral fractions in the soil. The same occurs with Cambisols, where the sand fraction was the 67.83%, while clay and silt fraction only reach 14%.

Totally opposite to those mentioned above are Vertisols, in which the prevailing fractions are clay (56.52%) and silt (42.80%), with sand averages lower than 1%.

The rest of the main units showed apparently similar granulometric compositions, with clay aggregates close to 20% except for the Fluvisols where this percentage has an increase up to a bit more of 25%, may be as a consequence of their fluventic origin and their physiographic location, predominantly valley bottoms and alluvial plains.

The pF values at 1/3 and 15 atm and, therefore, the water availability, showed that the most main units have levels ranging between 12 and 13%, so that, as it happened with the granulometric composition, we can assume that their hydrodynamic behaviour is very similar. Arenosols and Cambisols have statistically lower water availability values ($p<0,01$), in concordance with their sandy texture, while in Gleysoles and Fluvisols, values were 14.80 and 19.64% respectively, so higher than the media, although this diference has no statistical signification.

Table 1. Average values of water content (%) and principal granulometric fractions of surface horizons by RSG.

Soil Group	pF 1/3 atm	pF 15 atm	AW*	Sand (%)	Silt (%)	Clay (%)	Area (%)
Arenosols	3,85	1,66	2,19[a]	94,23[a]	2,37[a]	3,40[a]	0,24
Calcisols	23,59	12,16	11,43[b]	39,82 [b]	35,49[b]	19,98[b]	51,97
Cambisols	15,34	7,78	7,56[a]	67,82[a]	14,85[a]	14,28[a]	0,24
Fluvisols	34,43	14,79	19,64[b]	26,65 [b]	42,13[c]	25,47[b]	10,93
Gipsisols	26,21	14,38	11,83[b]	35,35[b]	41,94[c]	13,51[a]	3,26
Gleysols	25,90	11,10	14,80[b]	44,00 [b]	29,21[b]	23,5[b]	0,05
Kastanozems	25,79	12,73	13,06[b]	34,60[b]	39,89[b]	22,11[b]	0,05
Leptosols	29,78	16,75	13,03[b]	40,38 [b]	34,10[b]	19,14[b]	14,24
Luvisols	26,25	12,63	13,62[b]	38,01 [b]	34,81[b]	19,38[b]	0,38
Phaeozems	28,16	14,53	13,62[b]	45,04 [b]	33,40[b]	19,95[b]	0,48
Regosols	25,15	12,72	12,44[b]	36,97 [b]	37,52[b]	20,20[b]	14,86
Solonchaks	27,20	14,58	12,63[b]	32,87 [b]	44,26[c]	18,94[a]	2,59
Vertisols	33,00	20,90	12,10[b]	0,68[c]	42,80[c]	56,52[c]	0,05

Therefore, we can say that Calcisols, Leptosols and Regosols represent more than 80% of the soils of the area we are studying and according to their texture and water retention capacity they must have a very similar hydrodynamic behaviour, regarding the A horizon level. Fluvisols are on the fourth place with almost 11% of total surface. These soils showed a statistically higher clay percentage (99%, p<0,01) than Arenosols, Cambisols, Gypsisols, Solonchaks and as a consequence their hydrodynamic behaviour is expected to be different. The nine main units of remaining soils are scarcely represented, since they together do not reach the 8% of the surface, and their hydrodynamic behaviour, in accordance with the variables considered, must be similar to the three first soils. In the case of Arenosols and Cambisols, with higher sand percentages than other units (p<0,001), different hydrodynamic properties can be expected .

Eventually, Pearson correlation index has been obtained (Table 2) for the variables studied, and we can say that the pF both at 1/3 and 15 atm are well correlated with the granulometric components, particularly with the sand. Likewise, as for the water availability (AW) the best correlation occurs with lime.

Table2. Correlation (Pearson index) between soil water content and granulometric analysis.

	pF 1/3 atm	pF 15 atm	AW	Sand	Silt	Clay
pF 1/3 atm	1	0,930982365	0,909533383	-0,918501816	0,908744499	0,658574037
pF 15 atm		1	0,695027606	-0,942378689	0,872894029	0,767700954
AW			1	-0,736050239	0,795942793	0,423790508
Sand				1	-0,919147198	-0,824896878
Silt					1	0,546740641
Clay						1

After considering the results and, without regarding the main soils groups that show significant differences both in their texture and water retention capacity (AW) and which on the other side are those in percentage terms less represented in the area, we can state that these parameters do not determine the hydrodynamic soil properties, at least at the surface horizon.

In this sense, and bearing in mind that the water storage and movement are controlled by the texture and structure of horizons close to the surface (Duley 1939; Morin *et al.* 1989), we can expect that the structure development and stability in the soils studied will not be as homogeneous as the texture and therefore, the structure will be the main contributor to the soils hydrodynamic properties. Likewise , the soil use affect the infiltration capacity (Kutilek and Nielsen 1994) so that the different size pores distribution and continuity as well as the cracks present among the aggregates are deeply affected by it, what we can translate as a reduction of the water availability and the number of biopores (Francis and Knight 1993)

Conclusions

At the sight of the results we can conclude that:

1. In the area, 13 out of the 32 main soil groups are represented. These groups according to their relevance are: Calcisols, Regosols, Leptosols, Fluvisols, Gipsisols, Solonchaks, Phaeozems, Luvisols, Arenosols, Cambisols, Greysols, Kastanozems, and Vertisols.
2. According to the horizon surface texture (A), more than 80% of soils have a very similar composition and, therefore, their hydrodynamic behaviour in terms of this parameter must be similar.
3. Arenosols and Cambisols have textures whose predominant fraction is sand, with percentages of 94.23 and 67.83% respectively. Likewise, water retention capacity is very low (2.19 and 7.56, respectively). On the other hand, Vertisols have the highest percentage of clay and the lowest of sand and their water retention capacity is 12.10%. According to this, these variables can be used to differentiate the hydrodynamic behaviour of these soils..
4. The pF both at 1/3 and 15 atm is well correlated with the granulometric components and best of all with sand. Likewise, as for the water availability (AW) is best correlated with lime.

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