Enhancing inorganic carbon sequestration by irrigation management

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Introduction

$ Soils play an important role in the global carbon cycle.

$ Soils are the third largest active carbon pool.

$ Soil Inorganic Carbon (SIC) is the most common form of C in arid and semiarid climates (Lal and Kimble, 2000; Mermut et al, 2000).

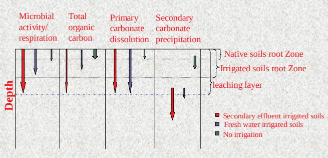
$ Soil Organic Carbon (SOC) is not likely to accumulate in cultivated semiarid and arid regions due to low formation rate and high decomposition rates induced by high temperatures and sufficient moisture due to irrigation.

$ The dynamics of the SIC is less understood than the dynamics of SOC (Lal, 2001).

$ Carbonate **precipitation is net carbon sequestration,** when the origin of the divalent cations is from a non-carbonate source (Monger and Gallegos, 1999).

Hypothesis: The use of water rich in nutrients and organic carbon (e.g., secondary effluent) for irrigation in semi-arid and arid regions results in more inorganic carbon sequestration compared to irrigation with fresh water

We developed a conceptual model (Figure 1) that illustrates the different scenarios, depths and intensities of the processes that contribute to inorganic carbon sequestration..



.Figure 1: A conceptual model showing the main processes that control carbon sequestering in the soil profile of virgin and irrigated soils of arid and semi-arid regions

Objective: To evaluate the effect of water quality on C sequestration in an inorganic form (i.e., as $carbonates_{(S)}$)

Materials and methods:

Study site: 3 sites with a similar soil (Kimberlina fine sandy loam) were sampled with a hand auger near Bakersfield CA. The sites were: A field which has been irrigated with effluent for more than 70 years, a near by field which has been irrigated with fresh water and a small field next to the fresh water field which has not been cultivated for at least 50 years. The soils were formed in alluvium derived dominantly from granitic and sedimentary rock.. The annual precipitation is 150 mm.

Sample analysis: Samples were air-dry and sieved with 2 mm sieve. Total carbonate was determined by the gasometric analysis.The particle size distribution was determined before and after carbonate removal (HCl 5%) by laser diffraction (Coulter LS 230). Carbonate dating was done by radiocarbon analysis on selected samples (Beta Analytic INC).

Results and Discussion

Carbonate distribution in the soil profile

A large variability was found in the carbonate profiles in all sites (Fig 2).

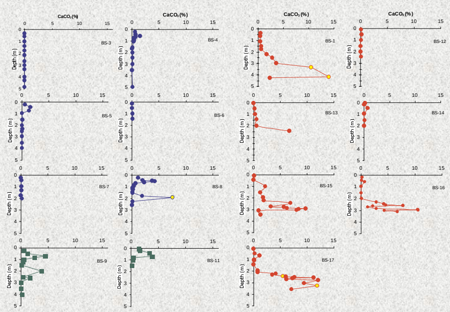


Figure2: Carbonate distribution in 3 different sites. Fresh water (blue), no irrigation (green) effluent irrigated (red). Sample points in yellow were dated by ^{14}C analysis.

Carbonate (as CaCO3) content in the root zone (0-2 m) of the two irrigated fields was significantly lower compared with the non-cultivated one. No significant difference in carbonate content between the effluent and fresh water irrigated fields was noted at that depth. The depth at which the majority of the carbonate was found in the effluent irigated field (2-4 m) was well below the zone of most active root growth. In a similar field irrigated with fresh water and the one with no cultivation less carbonte accumulated and most was at a shallower depth (Table 1).

Table 1: Mean carbonate content in the studied sites .

Type of irrigation water	Carbonate content 0-2 m		2-4m	
	# of profiles	Mg/ha/depth	# of profiles	Mg/ha/depth
Effluent	7	92.6 b	4	1172 a
Fresh	6	68.2 b	3	8.7 b
No cultivation	2	323.6 a	1	192.2 ab

Within a column, values followed by the same letterr do not differ significantly (0.05 probability level).

Particle size distribution

In general, an increase in clay due to carbonate removal suggests that the carbonate acted as a cementing agent, and depletion in clay due to carbonate removal suggests the presence of clay size carbonate.

In fresh water irrigation, no significant addition or depletion in the clay content was noted along the profile following carbonate removal (Fig 3a).

In the effluent irrigated field, only depletion in the clay content was noted after carbonate removal, mainly in the deeper half of the studied profile, which suggests that a significant fraction of the carbonates were present in the clay size fraction (Fig 3b). McCaslin and Lee-Rodriquez (1979) reported a similar pattern.

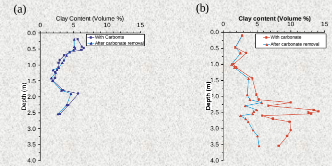


Figure3: The clay content before and after carbonate removal. (a): fresh water irrigation (BS-8), (b): effluent irrigation (BS-17).

Radiocarbon dating

The radio carbon dating and the lighter C ($\delta^{13}C$ = -11.4) data suggest that the bulk carbonate in the soil sample from fresh water irrigated field is relatively recent (Table 2).

A trend was noted in the radiocarbon dating and $\delta^{13}C$ values in the samples from the effluent irrigated field; the deeper the sample the older and heavier the carbonate (Table 2). These results may suggest a mixture of old and recent carbonate, with a considerable anthropogenic contribution.

Table 2: Radiocarbon dating and $\delta^{13}C$ values of selected samples

Sample #	Depth (m)	Radiocarbon age (Years BP)	$\delta^{13}C$
------------------------ Fresh water irrigation ------------------------			
BS-8/15	1.9	1410±40	-11.4
------------------------- Effluent irrigation --------------------------			
BS-17/11	2.4	4100±40	-5.1
BS-17/19	3.24	6080±40	-2.2
BS-1/9-10	3-4	7030±120	-4.2

Summary and Conclusions

6 Similar carbonate contents were noted in the root zone (0-2 m) of the two irrigated fields.

6 Below the root zone (2-4 m), more carbonate was found in the field irrigated with effluent.

6 The significant presence of clay size carbonate, in the samples from the field irrigated with effluent, may suggest that secondary precipitation of carbonate occurred.

6 The radiocarbon dates neither support nor negate our main hypothesis. No clear effect of water quality on inorganic carbon sequestration was noted.

6 A more detailed future stable isotope analysis (e.g. C, O) may help to clarify the complex picture.

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